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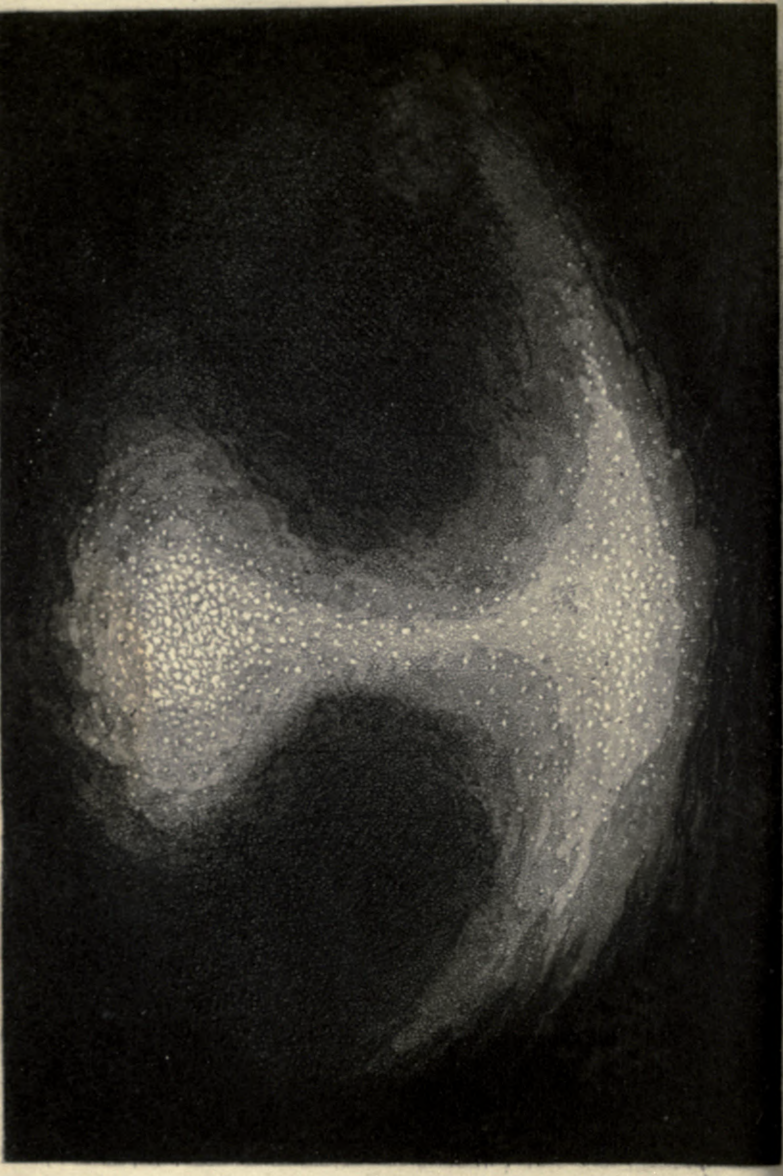

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PREFACE.

I HAVE been induced to publish this volume by two classes of considerations.

In the first place, the action, although only begun, of the great telescopes which Science owes to the genius and labour of the Earl of Rosse, have somewhat altered the views I formerly gave to the public, as the highest then known and generally entertained, regarding the structure of the Heavens: and I deemed it a duty to offer, by way of Supplement to my previous work, a brief and early account of the modifications thereby impressed on the questions it undertook to discuss. These modifications are, in every way, remarkable in detail; witness the extraordinary revelations regarding the shapes and internal constitution of the Stellar clusters, which, through the kindness of that Noble Earl, I am enabled very fully to present: but, in regard of one special and very important point, his Lordship has wholly subverted the opinion of his illustrious predecessor. The supposed distribution of a self-luminous fluid, in separate patches, through the Heavens, has, beyond all doubt, been proved fallacious by that most remarkable of telescopic achievements — the resolution of the great Nebula in Orion into a superb cluster of Stars: and this discovery necessitates important changes in previous speculations in Cosmogony. What these are, as it appears to me, I have now thoroughly unfolded, — not being disposed, however, to regard such speculations as unwarrantable in our former state of knowledge, nor agreeing with many inferences that have recently been drawn from them by Inquirers of very various and opposite views. As I cannot otherwise better express my opinions regarding the general bearing of these cosmogonies, I shall take the liberty of repeating a few sentences from my previous work: — "Suppose we are yet mistaken; suppose the Nebular Hypothesis, with all its grasp, not to be the true key to the mystery of the origin and destinies of things, what is gained—what new possession—by that course of bold conjecture on which we have ventured to embark? This, at least, is established on grounds not to be removed. In the vast Heavens, as well as among phenomena around us, all things are in a state of change and PROGRESS: there too—on the sky—in splendid hieroglyphics, the truth is inscribed, that the grandest forms of present Being are only GERMS swelling and bursting with a life to come! And if the Universal fabric is thus fixed and constituted, can we imagine that aught which it contains is unupheld by the same preserving law, that annihilation is a possibility real or virtual—the stoppage of the career of any advancing Being, while hospitable Infinitude remains? No! let the night fall; it prepares a dawn, when Man's weariness will have ceased, and his soul be refreshed and restored.—To COME!—To every Creature these are words of Hope spoken in organ tone: our hearts suggest them, and the stars repeat them, and, through the Infinite, Aspiration wings its way, rejoicingly as an eagle following the Sun."

I have recently seen also, with some astonishment and not without much concern, the unexpected prevalence, manifested in various forms, of the most strangely inaccurate and conflicting views as to the connexion of larger inquiries regarding the Order of Nature, with points of the deepest interest to man, viz. his conception of his own position and duties amid the Universe, and, as a matter of course, his relation, as well as that of all things, to the Providence of the unchangeable Creator; and from these, in the one way as in the other, I rejoice exceedingly to find an opportunity of expressing my decided but respectful dissent. The reasons of that dissent, will be understood by any one who shall favour me by perusing carefully the following pages; nor perhaps can I give a better expression to my feelings than in the brief words of a valued friend yet destined to hold, if he is spared in life and health, one of the most distinguished places in the science and literature of the country, "God literally creates the Universe every moment. Every instant is a new morning of Creation. He is the Alpha and the Omega, the beginning and the ending; the Creator, the Sustainer, the Provider, 'in whom we live, move, and have our being.'"

When I thought it advisable — now ten years ago — first to introduce to the British public a notice of these great truths in Astronomy, I placed the following words at the beginning of that treatise, "I have been induced to make public this brief series of letters, because of a regret which, I believe, is widely felt, that the discoveries of recent years, which have thrown most unexpected light upon the constitution — present and remote — of the Stellar Universe, should longer continue comparatively unknown, or concealed amid the varied and massive collections of our Learned Societies." The times, however, have vastly changed since then; indeed in so much, that whether through inspection of original documents or not, those views are now found generally unfolded in books touching on any question concerning the Nature of Things; and they are discoursed of in almost every popular periodical, as having passed within the domain of common knowledge. The necessity that induced me to attempt this course of exposition, has therefore ceased to exist; and unless leisure permit that, in performance of an old promise, I can execute during next autumn, a specific book on Geological Phenomena and their causes, I intend to intermeddle with these peculiar themes no more—having already lingered among them, perhaps, too long; and shall therefore, with all gratitude, offer my respectful Farewell.

In reference to the Plates in this volume, I must acknowledge my great obligations to Lord Rosse. The remarkable Spiral Nebula is now published for the first time, through his kindness; and I am glad to state, that—aided by willing and ingenious artists—my rather venturous attempt to represent these masses of stars in the light in which they appear—viz: *white* on a *dark ground*, has been considered by his Lordship to be successful.

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ERRATA.

Page 95, line 3 from below, for Ursa, read Ursæ.

At the bottom of page 111, an expression—imperfectly worded—may be misinterpreted. It is not meant that the globular clusters have changed since Herschel's time; but that, as we must now accept the Nebulous Stars as Clusters, we have before us a series of a perfectness which even he did not admit.

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PART I.

THE MATERIAL UNIVERSE, AS REPRESENTED IN SPACE AND TIME BY THE GRANDER PHENOMENA OF THE HEAVENS.

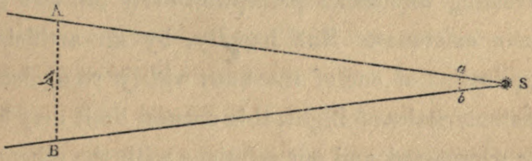
CHAPTER I.

GLIMPSES OF KNOWLEDGE REGARDING THE STRUCTURE AND EXTENT OF THE SIDEREAL ARRANGEMENTS.

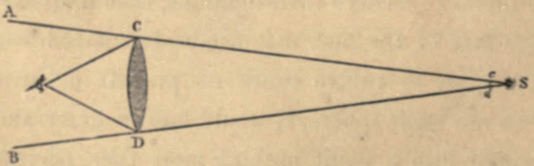
THOUGH it is less the object of this first part of my volume to recount the knowledge we have acquired regarding the arrangements and structure of the Heavens, than to illustrate in how far our previous conceptions are likely to be modified by the course of discovery on which our age is happily entering, I yet feel the special facts to be in themselves so marvellous, and seemingly removed so far beyond the sphere which man can definitely explore, that I must crave leave, at the outset, to recapitulate certain general principles which I have elsewhere fully discussed, and by whose aid alone we can speculate concerning Forms distributed amongst the deepest profundities of Space.

I.

The power to pass beyond the limits of natural vision, we owe to the TELESCOPE. Now, the principle on which that power depends, is extremely simple; so much so, that the first and rudest instrument contained a full and manifest expression of it: but, as usual with every acquisition of man, it was only after the continued efforts of centuries — not, indeed, until our own times—that we have seen elaborated its complete and probably ultimate efficiency. In order to the irritation of the nerve of vision in the human eye, or to the production of the sense of seeing, it is necessary that a certain intensity of light enter its small pupil. But, since the magnitude of that pupil remains always nearly the same, and since—in consequence of the fact that the rays issuing from any luminous object pass from it in straight lines — the mass of light diffused by it over a given surface becomes gradually thinner as the distance of that surface from the shining point is increased; (as much light, for instance, falling on the straight line *a b*, as is spread over the whole of the much larger one A B,); — it is clear that, as



the eye retires farther and farther from the neighbourhood of S, it must, through effect of the diminishing intensity of the pencil that can enter it, receive from it less and less light at every consecutive stage; and that a point of remoteness would soon be reached beyond which that pencil could suffice no longer for the purposes of human vision, and where the stars would therefore necessarily pass from among perceptible objects, into the dark unknown. In regard of the celestial orbs, it seems, from Sir William Herschel's investigations, that if an average star of the first magnitude were withdrawn into space to twelve times its present distance from our solar sphere, it would lose its glory and dwindle into a point nothing more than perceptible: so that, speaking generally, the countless luminaries beyond that limit, shining though they do through every portion of space, and working out untiringly the great purposes of the Eternal, must, had we been unhelped by science, have blazed amid these recesses for ever, without revealing to human perception even the fact of their existence. But happily, by an artificial application of one of the most widely recognised characteristics of Light, this natural limit may be far overpassed, and our relations with the scheme of visible things entirely changed. If, as in the diagram below, by the mere intervention of a peculiar transparent plate, C D, the whole rays falling on its large surface, could, as they pass through it, be turned from their previous courses, and made, on the contrary, to converge or collect themselves at the pupil, into a pencil small enough to enter its narrow opening, it is clear that the eye would now receive the entire mass of light comprised between the two radii A S, B S, instead of the veriest fraction of it, as before:



the star, no longer on the verge of invisibility, would shine with the splendour that would have belonged to it had the spectator received its whole direct beam at the line *c d;* and the bounds of the visible creation would become so much enlarged, that instead of being turned again at the barrier indicated by Herschel, one sees not a remoteness so profound, where the human senses might not pursue the radiance of these thronging orbs. The extent of this new and most unexpected power, is manifestly limited only by the size of the plate C D, (which, so far from being a mere supposititious agent, is the OBJECT GLASS of REFRACTORS, and the METALLIC MIRROR in the case of REFLECTING telescopes,) compared with the size of the pupil of the eye; for clearly by this proportion is measured the quantity of light effectively condensed: and if one considers that the average breadth of that small pupil does not exceed one-fifth of an inch, the power gained, and the revelations effected even by the smallest instrument, should cease to be matter of amazement. Tried by this standard of comparison, it is surely no wonder that the rude tube of GALLILEO sufficed to unveil the spots of the Sun; changed the surface of the Moon from a mottled, unintelligible disc, into a world checkered by mountains, valleys, and extensive plains;—that, to an instrument which one can carry in the hand, that speck of brilliant light, the planet Jupiter, reveals himself as a majestic globe, the centre and ruler of a large scheme of dependent satellites;—that Mars tells of his continents and oceans, and polar snows; and the distant Saturn displays his gorgeous ring:—less marvel still, that HERSCHEL, by gradually enlarging his metallic discs with the growth of his experience and mechanic skill, until he reached the perilous adventure of the four feet mirror, passed, by gigantic strides, through regions of the universe to which not even imagination, in its wildest moods, had essayed to penetrate before;—or that now, after enjoying their peaceful triumphs through the third part of a century, even *his* discoveries must again, in some directions, hide their heads, and speculations among the loftiest to which human reason will probably ever attain, and which seemed also among the surest, are doomed to undergo change or destruction, because of the achievements of a tube whose vast eye is SIX FEET in DIAMETER! This unparalleled enterprise, which it required the daring of highest genius to conceive, and skill the most consummate to accomplish, has now reached a triumphant close:

and although, from the nature of the objects to be examined, and the multiplex obstacles presented by the atmosphere and conditions of our Earth, years must elapse ere its task be greatly advanced, no doubt whatsoever can exist that it will achieve, in the work of Observation, an immortality as illustrious as that which, through all time, will belong to the only enterprise with which LORD ROSSE's can be associated — I mean the labours of TYCHO in his castle of URANIBURG.

The size of the lens or mirror is not merely a *general* indication of the power of the Telescope; inasmuch as if each instrument were tested separately, in respect chiefly of the reflecting or transmissive qualities of the metal or glass, we might obtain, by means of it, much more than a general or rough comparative estimate. But, since nothing is dependent on minute exactness in speculations concerning the enormous distances we are about to mete out within Infinitude, it is enough for present purposes that we can reach a tolerable approximation. Now, regarding his own telescopes, Herschel computed that the seven feet reflector had a power to penetrate into space, which, compared with that of the naked eye was 20¼; the ten feet, a comparative power of 28½; the twenty feet, of 75; the twenty-five feet of 96; and the forty feet, with its four feet mirror, the immense power of 192. It is not easy to compare Lord Rosse's telescopes with those instruments, inasmuch as their various relative qualities would require to be ascertained by direct experiment: but if, as seems fully established, his lordship's three feet speculum is much superior, in space-penetrating power, to the largest disc in possession of his great predecessor,* we shall be obliged to endow the six feet mirror with an efficacy to pass without difficulty into space, at least 500 times farther than is possible for unassisted vision: in other words, it will descry a single star six thousand times more remote than an average orb of the first magnitude,—or, though it were separated from our abodes by an interval so tremendous that, were a new star, at a similar distance created now, its light, even though its velocity be next to inconceivable, would travel through the intervening spaces probably for more than *sixty thousand years*, ere by reaching this Earth it could tell of a new existence having been summoned from the void! In presence of triumphs so signal, and so steadily progressive, I feel that it requires no little boldness to intimate that now we cannot be far from the term of our domain,—or that we have closely approached the limit of attainable, that is, of *useful* telescopic power. Certainly I am nowise appalled by the mechanical difficulties as to the *constructing* of still larger instruments; for Lord Rosse has shown that, in this respect, there is no hindrance which might not be overcome: but difficulties, nevertheless, of a description the most serious, occur in regard of the *employment* of great telescopes, and they increase rapidly with their size. Firmness of position, ease of motion, and the power of being made to pass through the smallest spaces in obedience almost to a touch, are characteristics indispensable to every instrument intended to afford measurements of value: and to ensure them for the six feet mirror, its illustrious maker has felt it necessary to *limit the range of its motion ;* and he has confined it within two massive parallel walls, between which it travels with an astonishing precision and facility, but thus sweeping only the immediate neighbourhood of the great meridian circle in the Heavens. Now, though the meridian is undoubtedly that circle whereon any celestial body may, on the whole, be viewed with most advantage, it is manifest that the limiting of an instrument to any one circle, must, because of the vicissitudes of our unstable atmosphere, vastly diminish the number of hours during which, in any specified time, it can be turned to the heavens with effect: and if, from the hours apparently effective, deduction be made of the many occasions during which, through the condition of the air, great magnifying powers cannot be employed, I shall not seem unreasonable in despairing of the useful application of specula much larger than what we now possess, to the purposes of discovery. The applicable size of a mirror must, in fact, ever be practically limited by the power of the applicable magnifier or microscope. The operation of a large reflecting or refracting disc is merely to present the image of an object clothed with an immense increase of splendour; but this of itself will not lead to a closer knowledge of the structure of the object, unless, by use of eye-pieces correspondingly powerful, we can diffuse its new illumination, or beat out the image over a large surface, *without impairing distinctness of vision*. Now, the internal state of the atmosphere, however cloudless it may seem, is very seldom quiescent. Currents of air, of different temperatures and densities, are, in most cases, rising and falling within it, with greater or less of frequency; and the crossing and constant intermingling of these produce, in regard of the external stars seen through so disturbed a medium, that same dancing or uneasy motion observed so easily near the surface of the earth during intense sunshine. This dancing or unsteadiness is, of course, magnified by the microscope: and so—often when low powers present an image distinct in its general features, and the observer is tempted thereupon to examine it with some higher one — precision and definiteness entirely vanish; and we are told, with sufficient emphasis, that there is a Fate the loftiest genius will never vanquish—that which confines man's successes within possibilities constituted by the conditions of his Earth.

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* It is wrong to suppose the space-penetrating power of a telescope simply depending on its *aperture*. Certainly a most important feature is the *definition*, arising from the figure of the speculum. Lord Rosse's telescopes derive their superiority chiefly from their excellence in this latter respect. To look through Herschel's four feet mirror, compared with the three feet, is like a short-sighted person looking at the stars without his spectacles.

II.

I should now examine the exact amount of *certainty* as well as *reach* constituted by the Telescope, in regard of the aspects of celestial objects: but again I must first advert, with some minuteness, to what also I have already explained to the public*— the nature of the grand fundamental truth relative to the distribution of the Stars in space. A thoughtful glance at the appearance of the skies on any cloudless night, necessarily excites the suspicion that those orbs are not, according to our earliest and common notion, strewn indiscriminately and without definite arrangement through the abysses of an environing Infinitude. I do not, at present, refer to minor groupings — like the Hyades or the Pleiades, or those other and manifestly special arrangements scattered over the sky, which, perhaps without much infelicity, have been thought to correspond, however dimly, with the mythic groups or figures that, for so long, have been known as the Constellations—but to that remarkable band, studded with visible stars defying enumeration, and with more, so blended together, that they transmit, towards the Earth, only a diffuse nebulous light,—a band surrounding, although with noticeable irregularity, the entire vault; and which has been recognised, in all ages, as the MILKY WAY. Now, what can we make of this gorgeous cincture—what is its strange and mysterious significance? If, indeed, we could measure the distances of all these stars, and so place them in their due positions on a plan or chart, the structure of the Heavens might be represented without blemish or mistake; but, no more than the unaided eye will ever penetrate to the limits of the Universe, shall it, through human Art, be able to take cognizance of quantities so small as shall guide it to the absolute determination of such remotenesses. Abandoning, then, the hope of certainty where that is clearly not to be realized, we must treat the question as one of probabilities; and a supposition, at least highly probable, meets us on the threshold—viz: that it may be allowed us to judge of the distribution of these orbs, on the ground that the *apparent diffe-*

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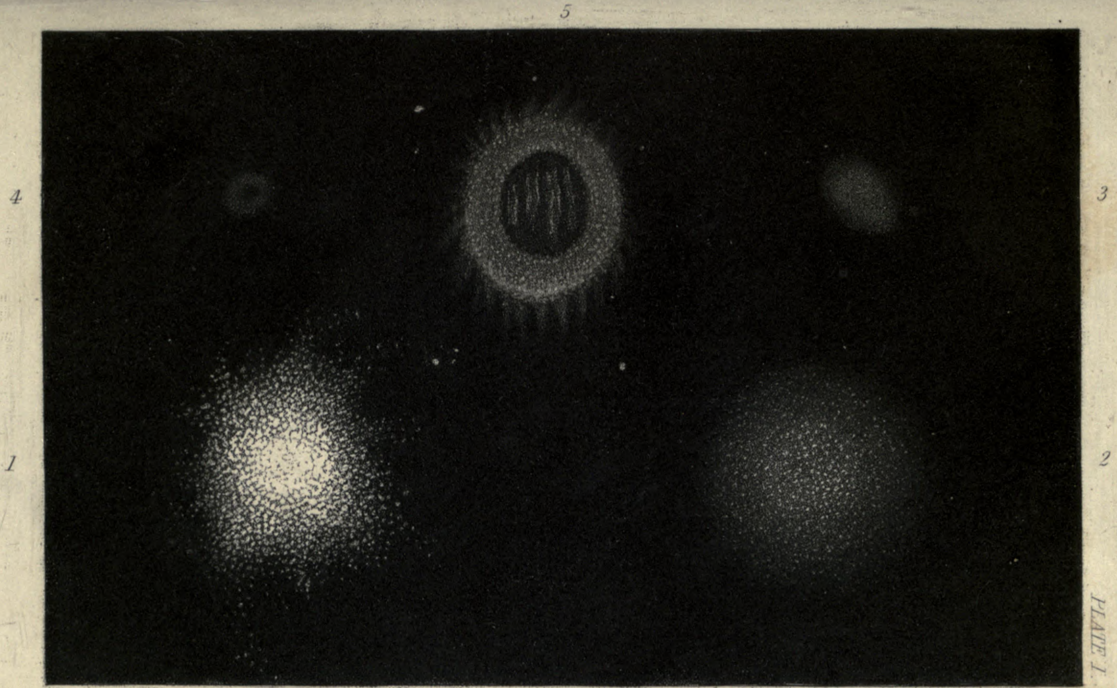
* In my volume entitled, *Views of the Architecture of the Heavens.*

rence in their magnitudes is, in the main, the effect of varying distance. The supposition, as must be at once confessed, is not rigorously true, for we know, from undoubted facts, that the stars also vary in *absolute magnitude ;* some being, perhaps, far more majestic than the Sun, while others do not reach one-third of his size: but, that the range of this class of variations is limited, and therefore does not, on the whole, interfere with the foregoing assumption, the general appearances of the Heavens readily confirm. For instance, not only does the number of the stars belonging to any magnitude, increase as that magnitude grows less ; but, until we reach the lower magnitudes visible to the naked eye, the number of stars of the different orders corresponds nearly with what should be found at their respective depths, supposing them equably scattered there, and of an absolute average size: nor is the correspondence seriously interrupted, until we penetrate near the region of the Milky Way, where all approach to uniformity of distribution gives place to special arrangements. Now, on the assumption that the *magnitudes* of the stars indicate, in the main, their *distances*, the general significance of that dazzling zone is not veiled in mystery. It unfolds its peculiar phenomena, unquestionably because *there* the starry Heavens that environ us, pierce farthest into the profound. In other regions of the sky, though indeed they are all most glorious, those orbs appear as not yet past reckoning, and as if the sphere within which they lie extended to no immeasurable depth. But in the direction of the Milky Way, magnitude succeeds to magnitude; and beyond even the clearest vision of the telescope, still there lie masses of that nebulous light — the blended lustre of multitudes of orbs that stretch into profundities which have withdrawn them seemingly for ever from distinct intercourse with man. Is it indeed possible, in contemplation of appearances so emphatic, to resist an impulse, however startling, to connect the conception of SHAPE with our stratum of stars? Is it not distinctly intimated by these phenomena of the Milky Way, that we are in the midst of a cluster or bed of orbs, thin or narrow at its sides, and inconceivably deep only at its ends, as if it were a flat circular zone, or thin slice of a sphere? Figure 1, in Plate II., will enable us to realize this unusual and next to overwhelming idea. It is the picture of a remote object, which, as we formerly saw it, seemed almost a fac-simile of our magnificent system. Now, let the imagination transport itself to a world near the centre of that galaxy — for it is a stupendous arrangement of stars at an inconceivable remoteness — and fancy the aspect of the Heavens around. In the midst of a bed of stars, exactly as we are now, the sky would sparkle on every side gloriously as ours; but in the direction of the ring alone would they stretch towards depths apparently fathomless: for though to us that whole arrangement seems only as a spot on the cerulean, its real dimensions may well be such as to baffle the longest sounding line. The conception of SHAPE as an attribute of our galaxy, thus leads almost irresistibly to that still more astounding conclusion as to its FINITUDE. No more than with that cluster, whose dim outline shines towards us across the abysses, are we entitled to imagine that our Heavens, with all their gorgeousness, are other than as one secluded islet amidst the boundless ocean of space; and it is surely no marvel when this thought, with its manifest concomitants, comes to be realized, that we feel as if the Idea of Existence in its plenitude, and of Infinity in its true awfulness, was for the first time dawning upon the Soul.

III.

The fact, that the cluster of orbs to which we more especially belong, is only a particular arrangement with a certain form and attributes, naturally leads to the conjecture, that this assembling and segregation of the stars into grand groups may be a chief feature in the structure of the sidereal Universe. It is indeed wholly unlikely that our group, as a single instance of a species, should rest alone and forlorn amidst desert untenanted Space; so that the notification is received without wonder, that the sphere of Infinitude through which the telescope has penetrated, *is thronged with similar clusters*, separated far from each other as islands in the great Sea. Now, on entering on the examination of such groupings, in search of intimations as to their general purpose, one difficulty considerably perplexing, instantly meets us; and it must be stated to the fullest extent, so that at least we may estimate its value if we cannot overcome it. It is clear that, unless through the *forms* of these distant groups, nothing satisfactory can be inferred regarding their character and meaning: but the question is, *how far can we rely that the telescope yields an absolute revelation of these forms*, — to what extent are we safe in speaking of what is *apparent*, as if it were *real?* The fact, that objects so distant, and in many instances so refined, would greatly change their appearances according to the power of the instrument through which they were viewed, was of course too obvious to escape the notice of any observer; and it was often adverted to by Sir William Herschel, especially in his memoir of 1818, where he hints at some general principles regarding the nature of this change. This inquiry, unfortunately, he did not carry sufficiently far to obtain any important conclusions: but as it is manifestly at once a legitimate and necessary one, I shall briefly endeavour, by comparing the varying aspects of a few specimen clusters as viewed by different telescopes, to ascertain whether these changes are of a kind that can induce us to conjecture concerning new revelations from telescopes yet more perfect, and whether there are any features or characteristics that may even now be eliminated as virtually fixed, and not liable to serious future modification.

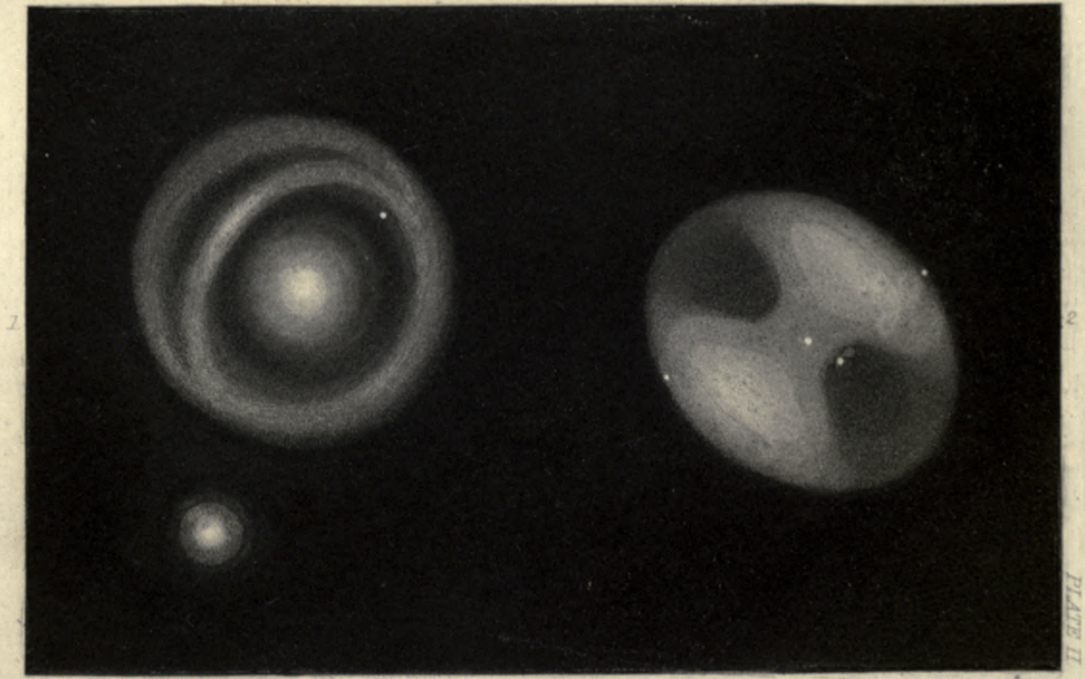
PLATE I.



J. Le Conte Sc.

NEBULÆ OF VARIOUS FORMS & DISTANCES.

PLATE II



J. Le Conte Sc

NEBULÆ, as seen by SIR J. HERSCHEL.

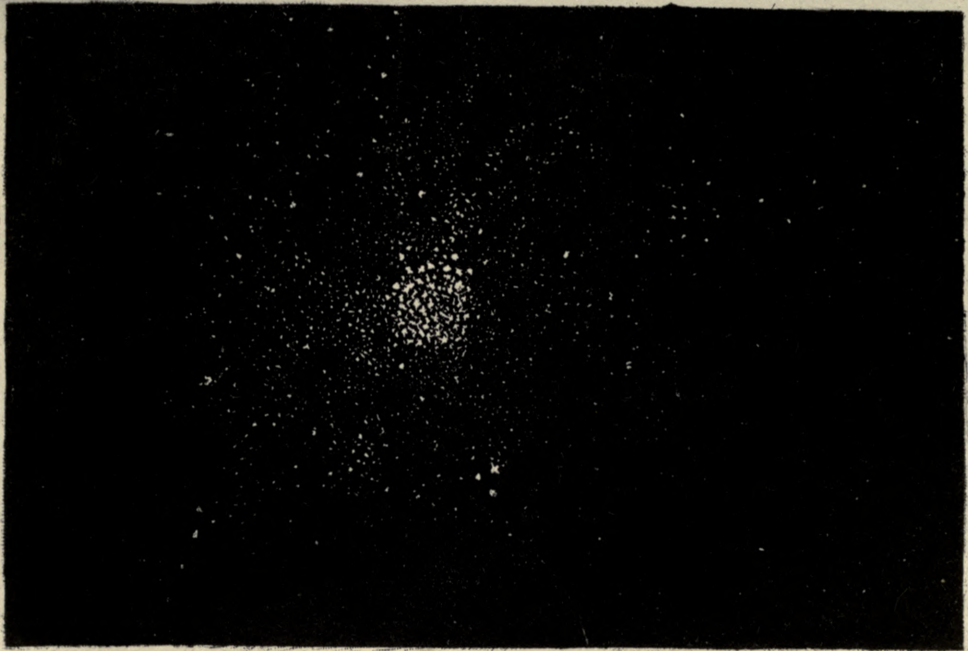
The general variety of aspects prevailing among these remote galaxies, considering them *en masse*, is the same for all telescopes. The class nearest us will always exhibit, for the most part, the appearance of that gorgeous cluster in Hercules, shown, as figured by Sir John Herschel, in Fig. 1, Plate I.,—the individual stars coming distinctly out, and merging, in this case, towards the centre of the group into one blaze of light. The class immediately behind these comparatively proximate objects, (I infer distance of course, on the ground of our previous assumption,) naturally shows, like Fig. 2, a much dimmer outline, with a far less brilliant development of individual stars, which there shine only as *star-dust;* while those remoter still, present, as indicative of their constitution, only the faint *granulated* aspect of Fig. 3, in the same plate, or the yet more unintelligible appearance of the nebula in Orion, copied in Plate VIII. from the graphic sketches of the same acute observer. The question, however, at present is, how do the nebulæ of each class appear to different telescopes? and this I shall answer by a few descriptive sketches.

1. It is plain that the application of additional

telescopic power must ever increase the number of resolved or resolvable (that is, *granulated*) nebulæ, at the expense of those which shine only with a dim and diffused light. This, accordingly, has already especially characterized the action of Lord Rosse's instruments, as explained by himself in his memoir of 1844; but probably a more interesting result is the *complete* resolution of others, which—although previously resolved,—for the most part retained in connexion with them, in some regions, a considerable portion of nebulous light. Even in the cluster in Hercules, that rich and gorgeous system, the central stars were not seen with perfect distinctness, so that this part of the group did not appear *pure;* but now every confusion arising from the blending of separate stars has disappeared, and the structure of the galaxy is wholly unveiled. In this and similar cases, the telescope must have pierced through the cluster, as well as surveyed its mere apparent surface; so that we may safely hazard the conclusion, that no farther light would be thrown on it by any conceivable increase of telescopic power.

2. The alteration, however, in point of resolva-

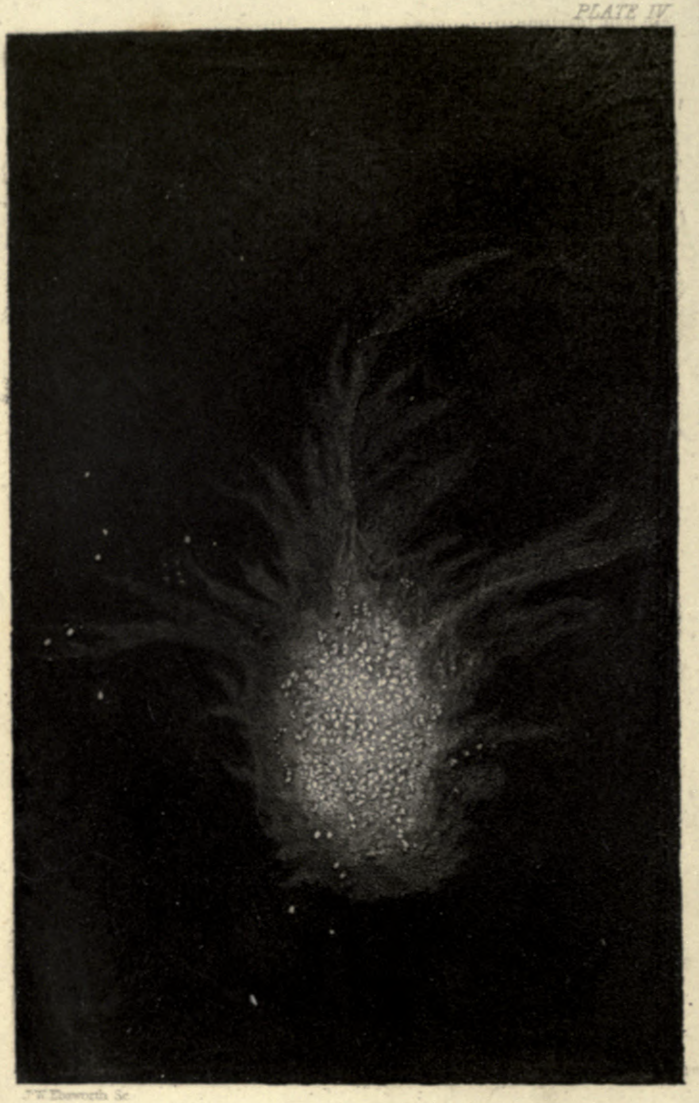
PLATE III



J. W. Ebsworth Sc.

FIG. 2. OF PLATE I. as seen by LORD ROSSE.

PLATE IV.

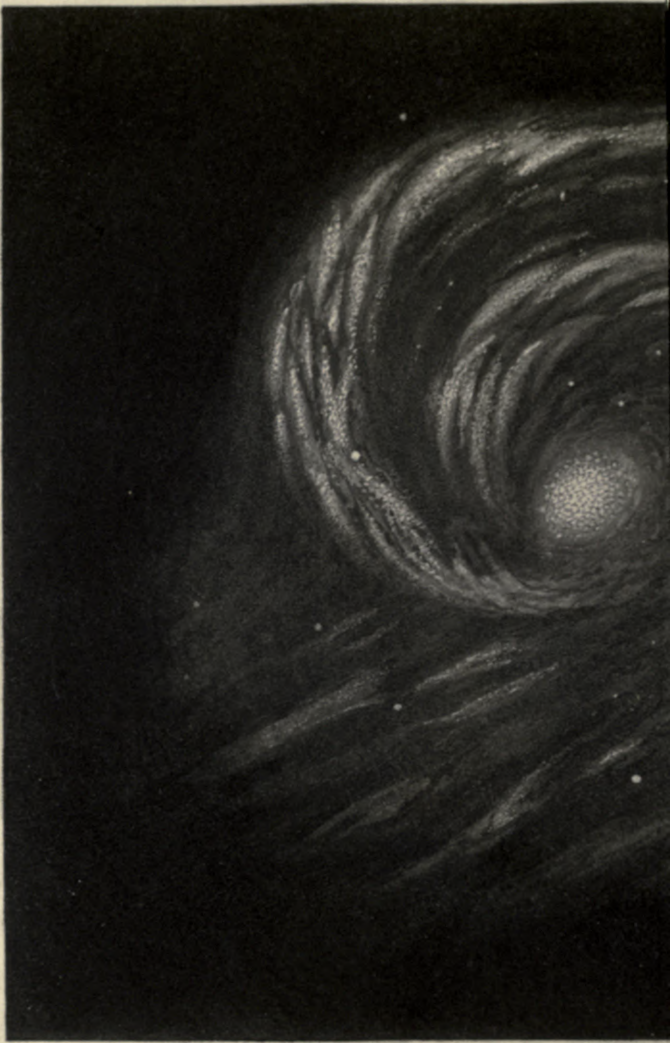


J W Elsworth Sc

LORD ROSSE'S CRAB NEBULA

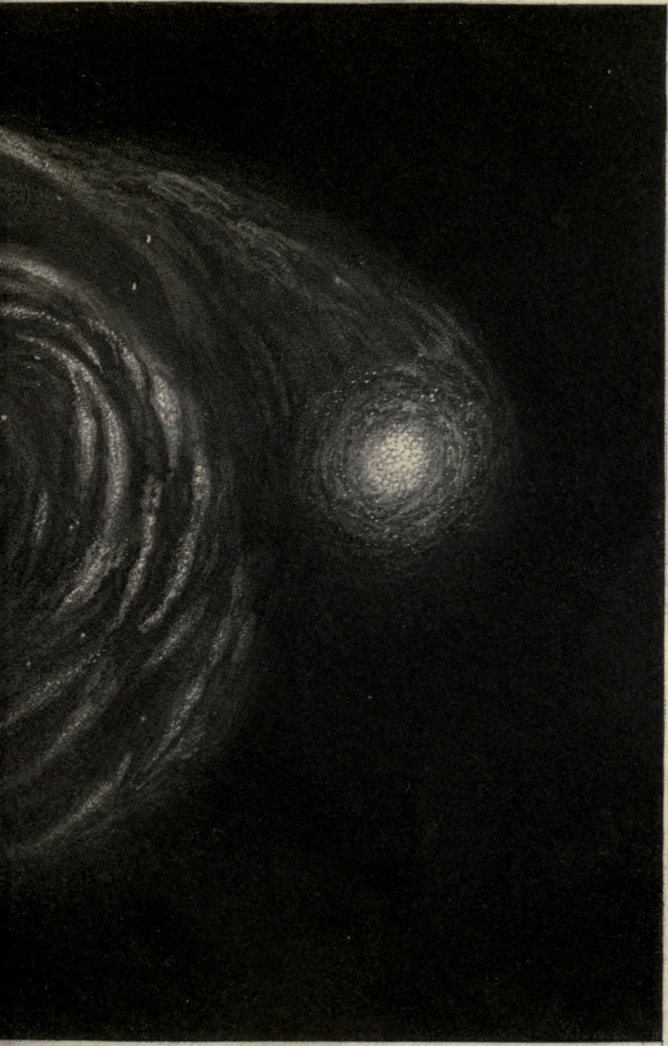
bility and distinctness which Lord Rosse has already impressed on those remote arrangements, is much less remarkable than the alteration of *form;* which is more striking when the form previously seemed the simplest. Figure 2, in Plate I., is a well-known nebula, and admirably figured by Sir John Herschel. Under the three feet telescope it bursts into the figure of Plate III. — a magnificent illustration of the comparative power of that great instrument, as well as of the probable nature of all clusters that we were wont to regard as nearly spherical. But much more strange is the metamorphosis, under the same telescope, of the nebula Sir John Herschel has represented by the form of Fig. 3, Plate I. That dull and obscure ellipse is then changed into the extraordinary object of Plate IV., where the fundamental ellipse is still visible, but which assuredly is far removed from simplicity. Those filaments, or subservient streams of stars, are wholly non-existent in the representation of the smaller instrument: and, since there is still around it a ground of nebular or unexplored light, it is inconceivable what streaks may not be added when it is subjected to the piercing glance of the six feet mirror. In both these instances, the most remarkable alteration, (besides distinct *resolution*,) is the revelation of those dim filaments hanging, as it were, by the central mass: and the same fact is noticed in regard of objects still more obscure. The circular nebula of Lyra, seen by Sir John Herschel as in Fig. 4, Plate I., has been transformed by Lord Rosse into Fig. 5, of the same plate: by the three feet speculum it was not resolved, although its granulated structure clearly indicated, that resolution was near: so that it, too, is a mighty galaxy, with parts of its stars attached to its mass in these irregular filaments or streams.

3. Turning to the dimmer objects; those which heretofore—half known and half only conjectured of—have rested on the very verge of the sphere of observation; it is there that we have chiefly been astonished by the feats of the new instruments. The Dumb Bell nebula is known over the world by the excellent drawing of it by Sir John Herschel, which I have attempted to reproduce in Fig. 2, of Plate II. Look at it in Plate V., (*Frontispiece*,) where it is as I have seen it with Lord Rosse's three feet mirror! No longer distinctness or completion of form, but a strange



J. Le Conte Sc.

THE SPI



NEBULA.

mass, internally most irregular, clustering apparently around two principal nuclei or knots of stars, and presenting, where it merges into the dark, the utmost indefiniteness of outline! But, in comparison with the object I have now to present, the metamorphosis of the Dumb Bell must move little wonder. The nebula formerly referred to, (Fig. 1, Plate II.,) situated in the Dog's Ear, seemed a portrait astonishingly close, of what we might conceive our own galaxy to be; and, although unresolved, it was by common consent considered a mighty cluster. Lord Rosse has seen it by aid of his six feet mirror; and Plate VI. exhibits its leading appearances. This plate, which is copied from the sketch shown by his lordship at the recent meeting of the British Association, (1845,) is an eye sketch only—unverified by micrometrical measurements; though these, when made, will alter no essential feature.* I do not insist on the mere fact of its resolution; for, although in one sense nothing can be more memorable than the conversion of these dim streaks of light into burning and rolling orbs, even a feat so grand and triumphant, in regard of the science and art of Man, has an attraction infinitely less than the transforming of a shape apparently simple, into one so strange and complex that there is nothing to which we can liken it, save a scroll gradually unwinding, or the evolutions of a gigantic shell! How passing marvellous is this Universe! And unquestionably that form would seem stranger still, if, rising farther above the imperfections of human knowledge, we could see it as it really is — if, plunging into its bosom and penetrating to its farther boundaries, we could develop the structure of its still obscure nebulosities, which doubtless are streams and masses of gorgeous related Stars!

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* This object is not singular in the Heavens. Lord Rosse has detected another of exactly the same character. It is very strange that shapes so odd should thus be reproduced. Another Nebula—the apparently simple form of 32 Herschel, has turned out a most fantastic figure, something like 8. The odd configurations of the *cactus* tribe in the vegetable world, would thus seem repeated among the stars!

IV.

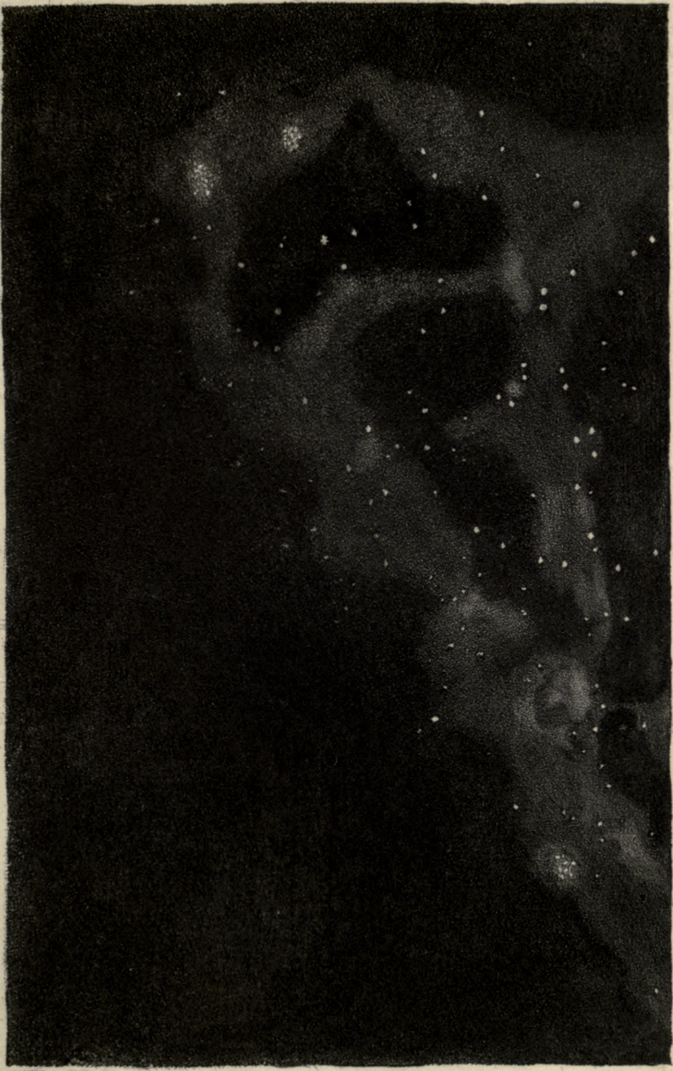
Under the guidance of the foregoing facts, it will now be in our power to undertake a review of the positive character of those magnificent groups. Warned by the changes undergone by their forms when seen by different degrees of telescopic power, we shall avoid the hazard of generalizing on the ground of what is apparent only, and not real or essential: but, by a cautious and reverential criticism, enough of stability may still be discovered, even amongst these shifting shapes, to intimate something of the high ordinances of the Eternal in regard of his grandest development of the Imagery of the Material World. It is not, however, to be forgotten, that we are here adventuring within the region of the onward twilight, and can reasonably hope for no more, than to trace, in dim outline, the forms of the august objects it contains.

1. Among the clusters of simpler form, it is difficult to doubt the preponderance of *great cen-*

tral masses — in all likelihood resulting from that power of *universal attraction* which prevails both in Earth and among the Heavens, as far as we have succeeded in unfolding their motions; — a power which may have originally determined the tendency of the orbs to segregate themselves into distinct groups, but which certainly seems to have a strong sway, at least over their *present* character. Whatever the irregularity of outline wherewith deeper telescopic insight has surrounded clusters which, like Fig. 2. Plate 1., at first seemed so simple; there yet uniformly appears as in the new form of that cluster in Plate III. a decided central mass, more or less compact; whose features are, in all respects, reconcileable with the energy of an extensive clustering power; and on which mass the irregular branches or filaments seem to depend. This may be said to be the case even with the cluster of Plate IV., and certainly it is true, with regard to Hercules, (Plate I. Fig. 1,) and all others approximately spherical. This same conception of the prevalence of a clustering power, Sir William Herschel conceived indicated by another feature of those globular masses. The light at their central parts, arising from the degree of compression among the orbs there, is not uniform, and bears no uniform relation to the size of the sphere within which the object is contained. It manifests, therefore, not a varying *apparent* concentration about their central regions, but a *real* variation: with this illustrious Observer, (for whose sagacity any more than for his daring, no speculation was too high,) it went to establish, amongst those groups, a series of aspects, each of which is a step in some stupendous evolution, to which, as the ages roll, they may be subject—bearing them onward from the condition of collections of stars comparatively sparse, to ripened spheres whose centres approach towards an uninterrupted blaze of light. The elevation to which this idea leads us is, indeed, a dizzy one, far aloft from the usual haunts of human thought: and yet why not the empire of Mutability, even over those dread Infinitudes, as well as among the mere shows and transiencies of Earth? Those galaxies are not the work of Man:—they are part of the ordinances of ONE below whose awful Unchangeableness, even processes whose solemn steps seem to occupy Eternities, may yet be, as before human vision, the opening of a leaf of the evanescent flower!

2. It is equally manifest, however, that,—considering them as *wholes* or *unities*,—we cannot, in our present condition of knowledge, discern in the interior constitution of more complex clusters any trace of law or order whatsoever. The products of the power just spoken of are essentially simple, provided they are *complete*, or are tending towards completion: their character is typified by the rain-drop, the shape of a planet, the compact regularity of the solar system, or by the cluster in Hercules: — Far other aspects greet the eye, when it gazes on the nebula of Plate V., or still more on the scroll nebula of Plate VI., with its countless dissevered parts and their capricious arrangements! But is the question unnatural or far-fetched — *ought we to regard such systems only as compact and completed* UNITIES? May we not, by examining them *by parts*, obtain glimpses, however dim, of processes affecting their nature? Doubtless, with all their complexity, they also, even in their entireness, are schemes internally harmonious; in which each part has its relative as well as its own proper significance; but the meaning of these wider relations may lie far beyond our reach, just as we shall never know the whole of the Universe's

fates. If then, with due limitation of purpose, we again look at Plate V., assuredly a portion of its first capriciousness seems to disappear. It contains within it, not one centre of attraction, like the simpler groups, but *two;* and around these, the orbs seem to have been clustering. With both the main masses, filaments and nebulous streaks — the remnants of its more uniform diffusion — are connected in abundance; and the nuclei are still joined by a bright stellar neck; but there seems no great boldness in the conjecture, that as the epochs of time are unfolded, that mass may separate into *two*,—with simpler features—still engirt by obscure branches — but more nearly approaching their ultimate form. The illustration from Plate VI., however, is much more striking, and bears closely on a problem relating to the structure of our own galaxy. However strong the sympathies pervading all that strange system, it is cognoscible by us, in the mean time, only as a collection of *separate masses;* nor can we err in so deeming it, through ignorance of its *real*, as compared with its *apparent* structure, inasmuch as it is the manifest tendency of the telescope to deprive these remote objects of apparent uniformity, and endow them with a constitution more and more discrete. Now, these parts are by themselves somewhat intelligible. The central spherical group has the form in which gravity would sustain any mass of stars; and most of the other segregated portions also can be conceived as partial schemes internally harmonious, or arranged in obedience to their internal sympathies. But the feature the most remarkable *for us*, is the character of the two principal lines of the scroll, or those two leading branches of that Milky Way, where the stars of the group appear mainly distributed; — it seems as if these beds of orbs were literally dissolving into fragments; which, in fact, is only *a repetition of the most conspicuous characteristic of the zone encircling our own galaxy*. That bright circuit is no regular belt, but, on the contrary, a succession of clusters, probably self-harmonious, stretching along its whole course, and separated by lines or patches more or less obscure. An eye-sketch of part of it in Plate VII. is a good illustration of its entire constitution; so that a vital or essential resemblance between the two objects seems beyond reach of doubt. Nor can it be denied, that the fact referred to in a previous note, viz., the existence of other Spiral Nebulæ of a similar constitution, appears



J.W. Ebsworth, Sc.

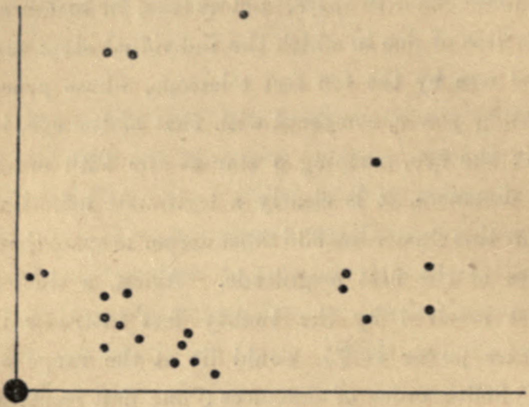
THE IRREGULARITIES OF THE MILKY WAY

to show that a *breaking down*, so to speak, of the masses, is not strange in the system of the Universe. Have we, then, here an intimation, however dim, of what is passing among those dread recesses? Is the apparent separation of our Milky Way into parts, in truth, as Herschel supposed it, in one of his loftiest moods, a mark of how far the shadow has passed along the dial of Time — a mystic but significant index of how much of the existence of that zone has gone, and a sure prognostic of its future course? If it is indeed so, and investigations on which we shall afterwards enter may confirm it, then we have before us another Infinitude besides that of Space. The marvels in our view must also fill up unfathomable Durations, and have received from their History much of what is mysterious and strange in the present aspects and conditions of their Being.

V.

One subject remains, to which attention must be directed in conclusion of our survey of the Sidereal Heavens. What is this system AS A WHOLE? Can we discern any law or principle in the distribution or mutual relations of these stupendous clusters as they are located in space? The question indeed is wholly beyond the reach of man's highest possible powers: but the endeavour to deal with it will unfold more of the majesty of that Creation, whose aspects we have been regarding. — Let us examine more closely its nature.

It was early discerned by Herschel that there are means by which we may arrive at an approximate conclusion regarding the locality in space of any *resolved* cluster; although, as in our previous inquiries, these also rest on an assumption. Carrying out the idea that stars are bodies of an average equality of magnitude, it is clear that, if the space-penetrating power of the telescope which *first resolves* a cluster, has been distinctly ascertained, no doubt can rest over the remoteness of that cluster in space. Let us take, for instance, the case of one in which the individual stars are *first seen* by the ten feet telescope, whose penetrating power, compared with that of the eye, is 28: the eye, reaching a star at the 12th order of distances, it is clearly a legitimate inference that this cluster lies 336 times deeper in space than orbs of the first magnitude. Again, a cluster first resolved by the twenty feet instrument, whose power is 75, would lie at the range of the 900th order of distances; one first resolved by the forty feet, would belong to the 2300th order; while those which first reveal their individual stars to Lord Rosse's stupendous mirror, would, if our computations be correct, lie six thousand times farther remote than the sphere of the brightest fixed stars! Herschel, in his Memoir of 1818, discussed this matter at considerable length, and ventured even to draw out a chart of the heavens, embodying the most prominent objects up to those of the 900th order. A fourth part of his chart is represented in the following woodcut, — the dark speck from which the lines proceed representing the size of all that mass of the stellar sphere taken in by the naked eye. It is difficult, unless by familiar illustration, to make a chart like this useful in conveying a true idea of distances. With that object, suppose the visible stellar sphere—that is, the whole sphere within the circuit of the 12th order of distances—represented by a common two feet celestial globe; then the boundaries of Herschel's chart would reach one hundred and fifty feet beyond its centre, and, were one extended as far as Lord Rosse's instrument can carry its resolving power, it must have the immense comparative radius of one thousand feet!



The portion of the chart now given—similar in all respects to the others—suffices to show the entire absence of apparent law, or order, or relationship, in the existing distribution of these grand constituent parts of the sidereal universe. And surely that is no marvel; for why should we expect such, in the mere fragment that we see? The individual nebulæ of which we have spoken seemed to us incomplete; because their *history* is hidden, and we are privileged to contemplate them in only one transient phase: but with regard to this grander phenomenon,—viz. that Sidereal Universe itself, of which they are merely individual parts, not only has Time not revealed the course along which it has been borne, but we descry no more than a small portion of it as it exists in Space. However potent the telescope, no man dare reckon that all things are taken in by its vision, or that it has penetrated to the outer battlements of this majestic Stellar Creation, any more than that, previously, all things were seen by his unassisted eye. Nay, the telescope itself, in every stage, has made very contrary declarations, and proclaimed how far it lingers behind a comprehension of the riches of Existence, even when unfolding so unexpected wonders. What mean, for instance, those dim spots, which, unknown before, loom in greater and greater numbers on the horizon of every new instrument, unless they are gleams it is obtaining, on its own frontier, of a mighty Infinite beyond, also studded with glories, and enfolding what is seen as a minute and subservient part? Yes! even the six feet mirror, after its powers of distinct vision are exhausted, becomes, in its turn, simply as the child, gazing on these mysterious lights with awful and hopeless wonder. I shrink below the conception that here—even at this threshold of the attainable—bursts forth on my mind! Look at a cloudy speck in ORION, visible without aid, to the well-trained eye: *that* is a Stellar Universe of majesty altogether transcendent, lying at the verge of what is known. Well! if any of these lights from afar, on which the six feet mirror is now casting its longing eye, resemble in character that spot, the systems from which they come are situated so deep in space, that no ray from them could reach our Earth, until after travelling through the intervening abysses, during centuries whose number stuns the imagination: —there must be some regarding which that faint illumination informs us, not of their present existence, but only that assuredly they were, and sent forth into the Infinite the rays at present reaching us, at an epoch farther back into the Past than this momentary lifetime of Man, by at least THIRTY MILLIONS OF YEARS!

If these majestic revelations, not in the mere rudeness and bareness of outward and obvious forms, but instinct with suggestive powers, gleam fixedly on the Soul, how awful its conceptions of the mysteries within whose lap it lies! The glories I have described, cannot be ALL: — Shrouded by the veil of day, they would, had the Earth, like the sluggish Moon, turned on its axis only as it revolves in its orbit, have been hidden hopelessly and for ever, by the garish beams of the Sun. Yes! though their bright haunts are always around us, and in virtue of the universal sympathies of things, they play upon our Beings unceasingly through influences and laws not yet unfolded, even their partial and interrupted cognition by the human spirit, flows wholly from a physical character of our globe, which perhaps might not have been! Is it not possible, then, that through other conditions of the Life to which we belong, and other limitations of our scheme of Senses, even now we are unconscious of being engirt by other Universes still more real and as vast as the World of Stars? What are those dream-like and inscrutable thoughts which start up in moments of stillness, apparently as from the deeps — like the movement of the leaves during a silent night, in prognostic of the breeze that has yet scarce come — if not the rustlings of near but unseen Infinitudes? But this theme should not be touched, unless by a master hand: —

"MYSTERIOUS NIGHT! WHEN OUR FIRST PARENT KNEW
THEE, FROM REPORT DIVINE, AND HEARD THY NAME,
DID HE NOT TREMBLE FOR THIS LOVELY FRAME,
THIS GLORIOUS CANOPY OF LIGHT AND BLUE?
YET, 'NEATH A CURTAIN OF TRANSLUCENT DEW,
BATHED IN THE RAYS OF THE GREAT SETTING FLAME,
HESPERUS WITH THE HOST OF HEAVEN CAME,
AND LO! CREATION WIDEN'D IN MAN'S VIEW.
WHO COULD HAVE THOUGHT SUCH DARKNESS LAY CONCEAL'D
WITHIN THY BEAMS, O SUN! OR WHO COULD FIND,
WHILST FLY, AND LEAF, AND INSECT STOOD REVEAL'D,
THAT TO SUCH COUNTLESS ORBS THOU MAD'ST US BLIND!
WHY DO WE THEN SHUN DEATH WITH ANXIOUS STRIFE?
IF LIGHT CAN THUS DECEIVE, WHEREFORE NOT LIFE?

CHAPTER II.

HERSCHEL'S SPECULATIONS REGARDING A NEBULOUS FLUID: THEIR GROUNDS AND OVERTHROW; EXTENSION OF OUR IDEAS CONCERNING THE VARIETY OF THE STELLAR CREATION. LAPLACE'S VIEWS AS TO THE GENESIS OF THE SOLAR SYSTEM, IN THEIR CONNEXIONS WITH HERSCHEL'S THEORY: FUNDAMENTAL IDEA OF THESE COSMOGONIES.

It was while contemplating the subject discussed in last chapter, that Sir William Herschel yielded to a speculation, as remarkable, probably, as any of so high a nature to which modern times have given birth, and which, accordingly, has exercised no slight influence over the tone of subsequent thought. I refer, as may be conjectured, to his theory of the Nebulous Fluid, founded on a supposed distinction among the *unresolved* Nebulæ, which induced him to believe that many of these milky spots are not remote galaxies, but, on the contrary, mere accumulations of a self-shining fluid, akin to the Cometic, and probably located, at no great remoteness, amid the interstellar intervals of our own Heavens. The grounds of this distinction, even though to higher insight they are at length known to be fallacious, were not, as we shall see, of a nature to discredit the sagacity of this extraordinary man; and his deductions, which grew into a splendid scheme of the genesis of the Universe of Stars, are memorials, not to be forgotten, of a Spirit, that with humility unabated, and ever deepening reverence, could rise of its own accord to the contemplation even of the beginnings, progress, and probable close of these stupendous material arrangements.

The Nebulous Fluid, as imagined by Herschel, could, it is evident, be distinguished from unresolved clusters, neither by the character of its Light, nor by its simple Irresolvability; for, while the illumination it transmits may easily be fancied of precisely the same dim and milky kind that is sent from remote galaxies, the mere attribute of irresolvability can avail nothing *of itself*, towards effecting a separation between classes of objects equally unresolved, and resisting with equal obstinacy the greatest telescopic energy. Masses of such a Fluid, and the unresolved Clusters, would indeed, when viewed apart, necessarily correspond so entirely in every external feature, that the endeavour to discriminate them in this way must be illusory; but if, on the contrary, *objects distinctly stellar*, were found in clear and positive *connexion* with a modification of matter so opposite; if, for instance, a Star and a Nebulosity chanced to exist in exactly the same portion of space—the star being plunged in the midst of it—it is easy to conceive that distinct evidence of *difference of nature* might then be deduced from *contrast of attributes.* Now, it was the belief that he had discovered a phenomenon of this precise and expressive kind, which first startled Herschel from the repose of his previous convictions, that all milky spots were clusters unresolved by reason of their remoteness; for according to his mode of contemplating them, the NEBULOUS STARS—that is, objects which he considered to be *stars enveloped in circular haloes*[*]—were inexplicable by any analogy drawn from his former knowledge. "In the first place," says he, speaking of a star of the eighth magnitude surrounded by such a halo, "if the nebulosity consists of stars that are very remote, which appear nebulous on account of the small angles their mutual distances subtend to the eye, whereby they will not only, as it were, run into one another, but also appear extremely faint and diluted; then what must be the enormous size of the central point, which outshines all the rest in so superlative a degree as to admit of no comparison? In the next place, if the star be no bigger than common, how very small and compressed must be those other luminous points, that are the occasion of the nebulosity which surrounds the central one? As by the former supposition, the luminous central point must far exceed the standard of what we call a star, so, in the latter, the shining matter about the centre will be much too small to come under the same denomination; we therefore either have a central body which is not a star, or have a star which is involved in a shining fluid of a nature totally unknown to us. I can adopt no other sentiment than the latter, since the probability is certainly not for the existence of so enormous a body as would be required to shine like a star of the eighth magnitude, at a distance sufficiently great to cause a vast system of stars to put on the appearance of a very diluted milky nebulosity." — I am especially anxious that the entire force and nature of Herschel's reasoning be here observed, for it is the foundation of all his theory. In presence of a phenomenon wholly unlike any other, and previously unobserved, or what is the same thing *unthought of*, the philosopher is choosing between two explanations, and selecting the likeliest. It is not a case where *certainty*, but only the highest *probability* can be attained; and they who will rest satisfied with nothing inferior to certainty, must abide in garish sunlight, and not follow Herschel, who here as elsewhere has adventured into that onward twilight where only gigantic shadows dwell. Now of the two explanations, he finds the one, viz., the supposition of a central body of enormous size, extremely improbable, since *we know of no such bodies*, and because of the likelihood, that if they did exist, we would—considering the *uniformity of Nature*—have had it in our power to recognise them in circumstances less ambiguous. The second explanation, on the contrary, is pressed by neither of these difficulties; for, in the first place, supposing it to exist, it could show itself under no aspect but that of a sparse shining spot; and besides, such a substance is known to exist, and to be closely connected—no doubt also for important purposes—with our own System. The Zodiacal Light, for instance—that bright cone streaming after sunset from our Luminary, might have seemed to belong to this modification of matter; and certainly the reality of such a modification is proved most abundantly by the Comets which—again prodigies, as they were of old—rush towards us from all quarters of the Heavens, and thus indicate the wide diversity and diffusion of their seats.

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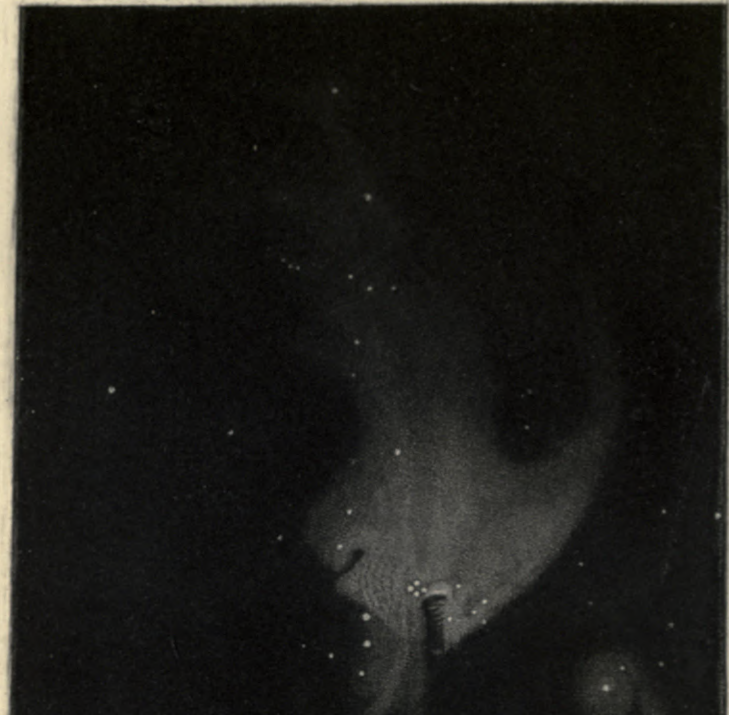
[*] These objects are very common in the sky. They present the appearance, precisely, of a regular fixed Star, with a cometic circular envelope. Those of my readers who have looked at my former work will recollect some of these objects as figured there.

Herschel's conclusion, however, may be withstood, by a criticism of a peculiar kind, the consideration of which will fortunately lead us to the argument for the Nebulæ, in all its generality, and unfold the extent of its application. How, it may be asked, did the Astronomer know that his star of the eighth magnitude *was really a star?* May it not rather be a *group of stars*, blended by distance into the appearance of a single orb; so that the entire object—star and halo—would only be an unresolved cluster with *great concentration at its centre?* Take, for instance, the cluster in Plate III. and suppose it carried backwards through space until its individual orbs grow invisible; might not it too become a nebulous star, — the central mass collapsing into the star, and the sparse branches and filaments into the environing halo? In its present condition it would unquestionably undergo no such apparent change. Fig. 2, Plate I. is the aspect of that Nebula to Sir John Herschel's telescope, and into that very figure it would necessarily grow under the eye of the three feet mirror on being withdrawn to profounder distances; this form, again farther dwindling into an object as faint as Fig. 3, of the same plate, (being circular only instead of oval,) and at a greater remoteness passing into invisibility. The brilliant cluster in Hercules, if gradually withdrawn, would exhibit similar phases; and so would every remarkable circular group yet noticed within our neighbourhood. Now, to realize the idea of what a nebulous star, considered as a cluster, must portend, let us try to imagine the change which, if impressed on the cluster of Plate III. would enable it at an adequate distance to appear as such an object. By what alteration, for instance, in its existing constitution, might its phase in Fig. 2, Plate I. be made to approach that aspect? Manifestly by none but this — the *vastly stronger compression of its central stars.* Now, these are already so much compressed that the overhead sky in that portion of the cluster must indeed be gorgeous beyond conception; but the degree of concentration required to assimilate it to Herschel's star of the eighth magnitude, at the distance to which his instruments could follow it, is altogether incomparable with that of its present constitution, and has no approach to similitude even amid all the variety around us. The supposition, then, that the star on which the astronomer reasoned was not in reality a star, but the distant aspect of the central part of a cluster of stars, thus leads us only into presence of a new improbability—a new exception to the order of surrounding arrangements: and, indeed, what wonder though even he who had clomb heights so lofty, and passed unbewildered through many untracked lands, should yet, in presence of a phenomenon which portended to summon into view schemes of being so unknown before, and so surpassingly dazzling, have felt that his imagination had lost its daring, and thereupon assumed as a refuge the easier and more probable hypothesis of a self-shining fluid, whose existence would veil the variety and temper the glories of this overpowering Universe!

But the reluctance to admit a compression so inconceivable, and the consequent desire for some simpler and less confounding explanation of appearances, leads much farther than to these encircling haloes. A considerable number of the diffused milky spots at present known in the sky are distinguished from the others by a remarkable feature, which, when duly analyzed, becomes exceedingly expressive. Speaking generally, the telescopic power required to resolve a cluster is not very much greater than that which first descries it as a milky spot: the interval between these two amounts of power, varies indeed, but nowhere, before our own time, had it been found to be very great. Now those nebulæ I refer to, appear not to be subject to this rule. Seen easily, in some cases, with the naked eye, they withstood even the entire amount of the immense telescopic power at the command of Herschel; — the nebula in Andromeda, for instance, being as inscrutable under the gaze of his largest instrument as it seems to unaided vision. It is necessary to apprehend the true significance of this distinction; and, with the desire to make it plain, I shall employ in illustration that well-known and beautiful group, the PLEIADES. This cluster, as it now exists, is the most interesting in our immediate skies; but supposing we wished to make it brighter, is it not clear that, to augment the united effect of its stars on the eye, we would simply *press them together more closely;* nay, that by this means, the group might be clothed with any amount of splendour — inferior only to the brilliancy of all its orbs, if concentrated into one gigantic globe? Imagine, now, the Pleiades as they are, to be withdrawn gradually into space, and let us try to represent their fates. Necessarily their individual stars would diminish in magnitude; the lustre of the group would slowly wane; soon it would pass into a faint nebula, and then disappear. But still let it pursue its track through that darkness, and conceive next, by what alteration in its constitution it might, at any point in its far course, be made to *reappear as a nebula?* Clearly by a *closer approximation of its stars,* even as we have seen that thus its brilliancy would be augmented now: the deeper it had gone, that compression would only require to be the stronger;

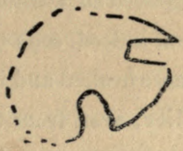
nor would it reach the boundary of absolute or hopeless invisibility, until the globe arising from the aggregation of all its stars would, notwithstanding its vastness, itself pass beyond sight. Now, if we knew not the character of this group, but at the same time could guess the distance from which, under a process of gradual compression, it had become capable of flashing on us as a faint nebula, how easy to conceive that a knowledge of its existence might reach us only under circumstances that would either oblige us to endow it with a degree of concentration, approximating perhaps even the final aggregation of its stars, or wholly to abandon the idea of its being a cluster? The theory of the self-luminous mist, precisely as in the case of the nebulous star, might thus again be forced on us, in order that we avoid the imagination of dispositions of orbs most strange and absolutely new,—not, indeed, because those dispositions are in themselves impossible, but because, in the existing condition of our knowledge and experience, it would less violate analogy to suppose that the cometic matter, even in stupendous masses, is not foreign to the interstellar spaces. And to this conclusion, and exactly on these grounds, Herschel felt himself constrained, in regard of all nebulæ *easily seen*, and not resolvable by his great instruments. I cannot require to repeat, that the irresolvability of a cluster by a telescope of eminent power indicates that it is located very profoundly in space, while the illustration just drawn from the Pleiades shows that *easy visibility* equally indicates the degree of concentration or compression of its stars. But, to avoid indefiniteness, let me turn to the special history of one great nebula, that in the sword of ORION. The naked eye almost discerns this nebula. On examining the middle star in the sword, it seems affected by an *indistinctness* not common to small stars; and the application of the smallest telescope at once yields the explanation — the object appearing not as a star, but a diffused haze. Examined with instruments of a profounder space-penetrating power, its character as a haze continues unchanged, though it speedily gives warning of some strange and fantastic object. To the ten feet telescope, for instance, which would descry a star nearly three hundred and fifty times farther away than the average distance of orbs of the first magnitude, the mist seems singularly shapeless, —something as below,—

PLATE VIII



NEBULA OF ORION, figured by SIR J. HERSCHEL.

J. Le Conte Sc.



but not a vestige of a star is discernible; and yet, be it observed, the light from that object affects the naked eye, although it is thus proved, if it be a cluster, to lie so remotely in space that the ray leaving it must travel through those immensities more than three thousand years ere it could reach our world! It is little wonder that even *then*, the nebula of Orion should have seemed inexplicable! Apply now Sir John Herschel's eighteen inch mirror. Not yet the remotest aspect of a stellar constitution, but the object figured in Plate VIII;—an object of which the revelation of the ten feet telescope is evidently the mere rudiment. Strange indeed those fantastic branching arms, but not less strange the apparent internal constitution of that extraordinary mass! So unaccountable seems it, and so unlike what had hitherto been known of collections of Stars, that the eminent astronomer, from whose sketch this plate is copied, averred, that, so far from showing a trace of stellar constitution, or even suggesting that, it rather suggested something quite different: —he had not then, indeed, seen the Scroll Nebula of Lord Rosse, whose broken and irregular mass removes improbability, even from the most strange idea, that stars wholly compose the wisps near the mouth of the Nebula of Orion. During Sir John Herschel's residence at the Cape of Good Hope, he examined this remarkable phenomenon in circumstances much more favourable than can ever prevail here, viz., when it was near the zenith, and, of course, seen through the purest portion of the atmosphere: but still there was not a trace of a Star, only branches added without number,—so as, if I rightly recollect the sketch exhibited by him to the British Association at Newcastle, almost to obliterate the Nebula's previous form. If a cluster, then, it has yet baffled our pursuit. Deeper still we may follow it, without lifting the veil of mystery beneath which its constitution is shrouded. During the winter of 1844-5, the Earl of Rosse examined it, with his three feet mirror, with the utmost care, and executed a drawing of it, which contained not a vestige of a star. There, then, the Nebula lay, separated from us—*if it be a cluster*—by an Immensity through which light could travel in no less than THIRTY THOUSAND

YEARS, and *yet visible to the naked eye!* Surely the imagination might well shrink from the admission of facts like these, — from the belief in a system of Stars so majestic, of splendour so concentrated, as, on the supposition that it is Stellar, we must attribute to that mass!

I approach the final resolution of all these doubts — the grandest revelation of modern times regarding the glory of the Heavens. No wonder that the scientific world watched, with intense anxiety, the examination of Orion, by the six feet mirror; for the result would either confirm Herschel's hypothesis, in as far as human knowledge would probably ever be enabled to criticise it, or unfold, amidst the Stellar groups, a variety of constitution not even indicated among the regions more immediately around our galaxy. About Christmas, 1845, I had the pleasure of visiting Parsonstown, and saw the Nebula through that mighty tube. It was—owing to the incompleteness of the instrument and unfavourable weather — the FIRST TIME that the grand Telescope had been directed towards that mysterious object: and although Lord Rosse warned me that the circumstances of the moment would not permit him to regard the decision then given as final, I went, in breathless interest, to its inspection. Not yet the veriest trace of a Star! Looming, unintelligible as ever, there the Nebula lay; but how brilliant its brighter parts! How much more broken the interior of its mass! How innumerable the streamers now attached to it on every side! How strange, especially, that large horn to the north, rising in relief out of the dark skies, like a huge cumulous cloud! It was still possible, then, that the Nebula might be irresoluble by the loftiest efforts of human art; but doubt continued to remain. Why, in an inquiry like this, the concurrence of every favourable condition is needful to success, may be readily comprehended. It is its aim to discern, *singly*, a number of sparkling points — small as the point of a needle, and close almost as the particles of a handful of sand; how easy, then, for any unsteadiness in the air, or any imperfection in the instrument, so far to diffuse the light of each that they would merge into each other, and thus become confounded in one mass! — Knowing his Lordship's intention to avail himself of all favourable opportunities, during winter, to penetrate, if possible, the constitution of this wonderful object, and impressed with the issues depending on the result of his examination, I anxiously awaited the intelligence. At length Lord Rosse wrote me the following memorable note:—

"Castle Parsonstown, *March* 19*th*, 1846.

"IN ACCORDANCE WITH MY PROMISE, OF COMMUNICATING TO YOU THE RESULT OF OUR EXAMINATION OF ORION, I THINK I MAY SAFELY SAY, THAT THERE CAN BE LITTLE, IF ANY, DOUBT AS TO THE RESOLVABILITY OF THE NEBULA. SINCE YOU LEFT US, THERE WAS NOT A SINGLE NIGHT WHEN, IN ABSENCE OF THE MOON, THE AIR WAS FINE ENOUGH TO ADMIT OF OUR USING MORE THAN HALF THE MAGNIFYING POWER THE SPECULUM BEARS; STILL WE COULD PLAINLY SEE THAT ALL ABOUT THE TRAPEZIUM IS A MASS OF STARS; THE REST OF THE NEBULA ALSO ABOUNDING WITH STARS AND EXHIBITING THE CHARACTERISTICS OF RESOLVABILITY STRONGLY MARKED.

"ROSSE."

And thus doubt and speculation on this great subject vanished for ever! The resolution of the nebula in Orion into Stars, has proved that to be REAL, which, with conceptions of Creation enlarged even as Herschel's, we deemed INCOMPREHENSIBLE, and shown that the laws and order of Existence on its grandest scale cannot safely be supposed as all compressed among the processes and phenomena around our homes. Yes! the Infinite we had built up after the fashion of what had become familiar, was yet, with all its greatness, only an IDOLA, and could fill neither Space nor Time. It was indeed a grand and noble Temple, but yet not the Temple of the Universe — issuing from the depths of whose awful adyta that solemn appeal again seems heard:— "HAST THOU AN ARM LIKE GOD, OR CANST THOU THUNDER WITH A VOICE LIKE HIM? GIRD UP THY LOINS AND DECLARE! CANST THOU BIND THE SWEET INFLUENCES OF THE PLEIADES, OR LOOSEN THE BANDS OF ORION? CANST THOU BRING FORTH MAZZAROTH IN HIS SEASON, OR BIND ARCTURUS WITH HIS STARS?"

—— And now, if only for a moment, contemplate that Stellar Creation in its unveiled magnificence! Restrained no longer by the consideration of probabilities, freed from the necessity of discerning amongst its mighty forms only resemblances of those developments of Power which more closely surround us, we can recognise no limit either to its stupendous extent or inconceivable variety. The nebulous spots resolved into Stars, is a fact which of itself vastly modifies our conception of the magnitude of that Creation: but how hopelessly does Imagination strive to enlarge itself, that so we realize the interior gorgeousness of these distant groups! In the masses of nebulous Stars, circular or compact galaxies of all orders of glory may now be traced, leading from the splendid cluster in Hercules, as their *lowest point*, up through schemes of being in which sun is nearer sun, until their entire skies merge into one blaze of light and one throng of activities;—not like ours, coldly studded with points far apart, whose mutual influences are sundered by huge abysses! But high above all stands ORION, the pre-eminent glory and wonder of the Sidereal Universe. Considering it as so remote, that its light cannot reach us in less than *sixty thousand years*, and at the same time as occupying so large an apparent portion of the Heavens, how stupendous must be the extent of that Nebula! It would seem almost, that if all other clusters hitherto gauged, were collected and compressed into one, they would not surpass this mighty group, in which every wisp, every wrinkle, is verily a SAND-HEAP of Stars! There are cases in which, though Imagination has quailed, Reason may still adventure inquiries and prolong its speculations; but at times we are brought to a limit across which no human faculty has the strength to penetrate, and where as now—as if on the threshold of the very Infinite—we can only bend our heads and silently ADORE !

II.

I proceed to another topic. The discussion of LAPLACE's celebrated theory of the birth of the Solar system, is certainly, in so far as my direct object is concerned, something of a digression; but, for obvious reasons, it is impossible to avoid inquiring in what manner and to what extent that ingenious cosmogony stands affected by the revolution in our views regarding the Nebulæ.

The origin of Laplace's speculation did not lie in Herschel's supposed discoveries. Contemplating our system as a whole, he discerned harmonies within it, and numerous adjustments unaccounted for by the presence of the law now upholding its mechanism; and these induced him to infer that this great fabric had a *primal constitution* as well as an existing life; just as the power which sustains the play of the human framework, may be conceived not to include that which first ordained the relationship and co-ordination of its parts. A glance at Plate IX, will enable the reader to understand distinctly what startled Laplace. Notwithstanding the great number of the orbs of which the system is composed, and the immense variety of their possible dispositions, the following fixed order, wholly independent of the existing action of the law of gravity, (which merely sustains the system as it now is,) is found to prevail :—

1. These various bodies move round the sun in ovals, nearly approaching to circles. They might, on the contrary, have moved in very eccentric orbits.
2. They revolve nearly in the plane of the Sun's Equator.
3. They revolve around the Sun, all in the same direction, which is that of his rotation on his axis.
4. They rotate on their axes, as far as is known, also in that direction.
5. The Satellites revolve around their primary planets, and also rotate around their axes, in the same normal direction.*

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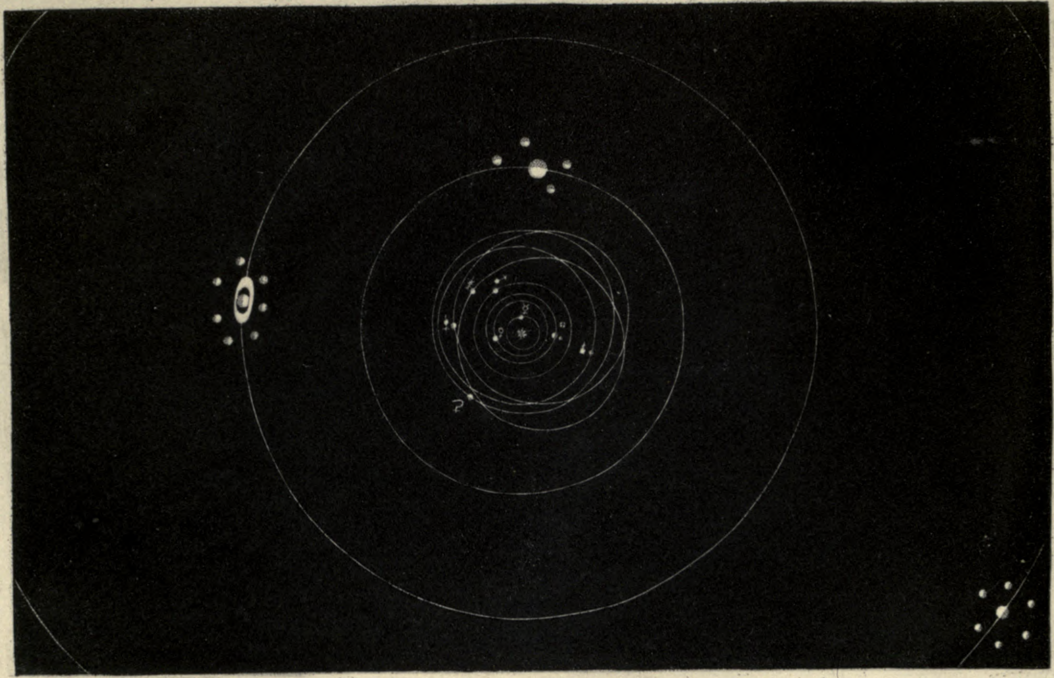
* The Satellites of Uranus are an exception, although the only one, to this law; and it seems a grave logical question at the outset,

PLATE IX.



J. Le Conte Sc.

ARRANGEMENT OF THE SOLAR SYSTEM.

That this extraordinary concurrence of motions and regularity of disposition cannot be the result of any fortuitous arrangement, is indubitable; but it has been questioned not unfrequently, whether Laplace was entitled to assume it as an indication of some natural process which, as the seed expands into the tree, evolved our exquisite system. The current objection is not easily characterized, but it amounts to this, — Why penetrate so far? Why not accept these arrangements as ultimate, or *absolutely* primal, — expressive of the plan according to which our system was formed by the immediate creative act? Now, to speak without the slightest reticence, I reply, unhesitatingly, that we are precluded from such a sup-

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whether, in face of this solitary exception, the Inquiry instituted by Laplace can be proceeded with on the grounds he has proposed. That the existence of the solitary exception has not been considered a barrier *in limine*, is evinced by the very general favour accorded to the investigation; and if no barrier *in limine*, it ought not to be pled afterwards that the Theory evolves no explanation of the anomalous fact. Still the fact is there—neither to be overlooked, nor reasoned away; and the question is, what shall we make of it? The probabilities of the case certainly favour the idea, that it is a *disturbance*, an interference with the order of the system, by some foreign law, or occurrence: but whatever *improbability* attaches to this solution, must go to weaken the whole Theory.

position, or from resting with such a solution, by the distinctest characteristics of the human mind. Placed, by the Eternal, in the midst of his gorgeous material Universe, with that unspeakable privilege of viewing Him as mirrored there through his high workings,—the Intelligence by which we interpret these workings has been stamped by Him who gave it, with conditions which it must obey. But, one of the most imperative of these conditions is, that we are bound, as by the inherent necessities of our being, to search for the explanation of every fact or phenomenon through its relations with some actual order, present or past.* Probably because Man is so deeply immersed in the stream of change, that the faculty would be practically useless, *no Power is given to him by which he can cognize beginnings:* around him on every side, replete with germinating causes, lies the dark Unfathomable. The effort to believe that we have reached a beginning, or, what is the same thing, to stake out a line beyond which, in some direction, Intellect must in nowise pass, has, indeed, never been uncommon: but, one after one, the artificial barriers have fallen; and, in virtue of the prerogatives given it by God, Inquiry has disowned the restraint, and burst all bonds!

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* In the strongest possible case, viz., that of a MIRACLE, do we not reach belief in it, simply by *first extruding all physical explanations as incapable?* And why are the absurdities of PAULUS of Heidelberg, and others of the fanatical infra-unspiritual school of Germany, received only with a smile? Just because they are independent of all law, and of every system, physical, moral, or spiritual.

Proceeding to interpret the foregoing special arguments by the principle thus started, it cannot be disguised that the leading phenomenon of the system, as a whole, is a *grand motion of rotation*, of which the rotation of the sun on his axis is only the central portion: and La Place soon saw that the main conditions of the problem would be satisfied, by supposing the planets to have somehow come into existence at the extremities of the solar atmosphere, while that orb, in the course of ages, was gradually contracting himself, or *passing from a gaseous mass into his present organized form.* Now it seems to have been here, and not previously, that the revelations of the telescopes of Herschel, whose fame was then spreading throughout Europe, attracted the notice of the distinguished Geometrician, and were assumed into his scheme. Receiving the Nebular hypothesis of the British Observer, La Place saw in the Heavens all the foundation his theory required,—masses of gaseous matter, in the first place formless and void; next exhibiting faint commencements of order; then characterized by distinct nuclei, gradually increasing in brightness, while the nebulous mass around them became fainter, as if it were being concentrated and absorbed; in fine, an unbroken series of condensations, whose final term was a fixed star with only a *bur* around it, not more remarkable than the zodiacal light which environs our Sun. Transport then this grand process to our solar sphere; accept these nebulæ and nebulous stars, as similitudes of our luminary at epochs of his past duration, and the fundamental assumption of Laplace loses the character of hypothesis—passing into a FACT.

The process by which this illustrious Inquirer unfolded the evolution of our system, simply by pursuing a rotating Nebula through all phases of its condensation, I shall not here examine in detail.* Concerning it, various judgments have at different times been arrived at, chiefly, as it seems to me, in accordance with the varying degrees of completion and definiteness expected from cosmological speculation : but unquestionably, among endeavours with aim so remote and lofty, it stands preeminent, if not alone,—not merely through the philosophical character of its grounds and method, or its success in grouping into one scheme so many diverse phenomena — gifting this fair work of the Eternal with the semblance of a Unity worthy of a Divine Idea; but probably yet more emphatically by assimilating even our mighty System to all the order of the World we understand,—subjecting even it to transiency, so that with the evanescent plant, it may be seen conspiring through the depths of the Ages, to work out the slow, solemn, and certain purposes of God.

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* I have thought it right, however, to subjoin the detailed investigation, to the present chapter, as an appendix, in the words of one who, of all existing Frenchmen, is perhaps the worthiest to occupy the chair of Laplace — I mean PONTECOULANT.

The change impressed by the resolution of the Nebulæ on this Cosmogony is at once very definite and very important. Deprived of the Nebulæ, it has no longer visible foundation in *fact*. The Sun may have passed into his present form out of a gaseous one; but there is no phenomenal proof of this — no visible analogical appearance in the Heavens. In addition therefore to the duty of explaining the peculiarities of our Solar system, Laplace's speculation *has now, along with* *other indirect arguments*, TO SUSTAIN THE WEIGHT OF ITS OWN HYPOTHESIS. To deduce the peculiarities of our system from a previous condition whose existence was recognised, and to demonstrate the reality of that previous condition, by remounting towards it from our existing epoch, are manifestly efforts of unequal difficulty, and very different ambitions. Internally compact as before, the scheme of this illustrious Geometer requires now to accomplish a task more arduous than it was framed for; and therefore it will break the easier at every feeble point. To hypothetical cosmogonies, Astronomy yields this as its contribution; and among such let it remain—interfering nothing with what is definite, sustaining no deduction which can affect positive science in its minutest department, but aiding, according to its power, to realize the unresting energy of the Creator.

In regard to the hypothesis of the cosmogony, it seems to contain nothing peculiar or new: for in such speculations it has ever been a favourite idea, that matter, in attaining the *solid* form, must have passed from the *gaseous*. The notion of huge aeriform masses in mere mechanical mixture, gradually losing their overpowering heat, and passing into a state in which, through the exercise of their manifold and exquisite chemical relations, all the various forms and uses of which they are susceptible could be unfolded, has been ever felt as a pleasing representation of the proximate origin of our own world; and it seemed to involve conceptions alike noble and lofty, when, with reverential daring, it was extended to the whole Universe of Stars. Realize for one moment the position of a tenant of a hut on the banks of the mighty Amazon, at one of its great bendings; tell him that the waters whose opposite bank his vision can scarce reach, are not an immense lake, but that, born of rills among mountains that are unseen, and ever increasing in depth and potency, they roll downwards until a whole continent is passed, and then mingle and lose themselves with an ocean engirdling the wide earth with its everlasting waves: so, in the view of these high cosmogonies, seemed to roll on those gorgeous stellar developments, whose limits no eye can now see,—rising among the past depths of Time in some hidden purpose of God—rolling onwards as these ages flow, and augmenting like the mighty river until the boundary of Time is reached, and their course ends among the quietudes of Eternity. Nor was this the entire of the splendid vision. There is indeed a sublimity in the abysses of Space and Time, replete even with an inanimate but ever-stirring mechanism; but the highest sublimity is in the strife of the Moral Will — in the victories of the Spirit over imperfection and pain. Now, in this grand array of worlds, unfolding during Time through long gradations into Principalities, and Dominions, and Thrones, — what have we save a mighty Theatre, whose drama must rise in solemnity, even as it extends, — that drama, I mean — — that contest with *Finitude* which must prevail wherever the Immortal is enclosed within the Finite; and which, though an essential, is not a peculiar attribute of the condition in which Man is placed? Yes! there must pass through all these worlds—its dread interests deepening as they grow —the various stages of the strife and heroic struggle, on whose banner is, ONWARD! The cry of the weak for succour, the trusting prayer of the victim, the voice of high aspiration, and the grateful song of him that overcometh, long as these grandeurs endure, must be ringing through all their spaces, clearer than the spheral music, and flooding onwards, unresisted, up even to where the GREAT GOD dwells for evermore!

APPENDIX TO CHAPTER II.

EXPOSITION OF LAPLACE'S COSMOGONY, BY PONTECOULANT.

I HAVE not chosen to disturb the expositions in our text by any detailed account of the Cosmogony of Laplace ; but as so much has recently been written, of a conflicting character, concerning it ; I think it may be interesting to many readers, should I here add, by way of note, a recent elaborate paper on the subject by Pontecoulant. It will of course be noticed, that whatever this illustrious Astronomer says regarding the Nebulæ must be abstracted. The paper, however, will present, independently of this, a full view of the internal compactness of Laplace's scheme, as that has recently been received.

"It seems a great deal to have discovered the true laws of the celestial motions, and to have been able to assign, with so much probability, that it almost amounts to certainty, the cause which produces them. It might have been thought that man ought to rest here; but in science, as in every other thing, success more frequently rouses ambition than satisfies it. Master of the great secret employed by nature to give life to the planetary system, this glory has not sufficed him; he has sought, by going back to past ages, to pierce even the mystery of its formation, and he has dared to conceive the bold thought of assisting, if we may say so, at the spectacle of the creation of the world.

"Buffon was the first to start this vast question, and to consider from this philosophical point of view the constitution of the universe. His ideas on the primitive formation of the planets and satellites would find few supporters among astronomers now: but we ought not to avoid mentioning them; it is a homage due to all creative geniuses, who even by their errors have contributed to the advancement of science by opening a road for the more fortunate speculations of their successors.

"Buffon supposes that the force of a comet falling obliquely on the sun, has projected to a distance a torrent of the matter of which it is composed, as a stone thrown into a basin causes the water which it contains to gush out. This torrent of matter in a state of fusion has broken into several parts, which have been arrested at different distances from the sun, according to their density or the impetus they received; they then united in spheres by the effect of motion of rotation, and, condensing by cold, have become opaque and solid, and formed planets and satellites.

"This system explains very simply the unity of direction of the orbitual motion of the planets, which all circulate, as is well known, from west to east, round the sun; but it is not the same with the rotatory motion, and we can find no reason why this motion should be in the direction of the orbitual motion rather than in the contrary one.

"Now this identity of the direction of the rotatory and orbitual motions of the planets and satellites, is one of the most remarkable facts pointed out by Observation. We see no better why the orbits of the planets are all nearly circular and comprised in a narrow zone of the celestial sphere, whilst the comets move in orbits very eccentric, and in any inclination whatever to the ecliptic. The hypothesis of Buffon is thus very far from explaining the principal phenomena which characterize the planetary system, and cannot now merit a serious examination.

"Let us try, with Laplace, to find out their true cause in another way. This new system, has for its support the labours of W. Herschel, aided by his powerful telescopes in regard to the *nebulæ;* by which appellation those whitish spots, seen in different parts of the heavens, of which they occupy a large extent, have been called. Observing these spots attentively, the nebulous matter is at first seen in a most diffused state, and reflecting only a feeble and almost uniform light; in others this matter is condensed round one or several dim parts; in others these centres are more brilliant in proportion to the nebulous matter surrounding them; afterwards the atmosphere of each body separating, by an ulterior condensation, there results numerous nebulæ, formed of brilliant bodies near each other, and each surrounded by an atmosphere; at last, a higher degree of condensation changes these nebulæ into stars. Classing together these observations on a great number of different nebulæ, Herschel supposes that they represent a series of operations on a single mass of nebulous matter, which would pass from its first state of completely diffused, scarcely luminous nebulosity, to the state of the most brilliant stars. The progress of the condensation effected by this change, could only become perceptible after the lapse of centuries; but we may discover it by examining at once the whole of the nebulæ diffused through the sky, as a naturalist who wishes to discover the successive developments of the organs of an animated being, studies them in individuals of different ages.

"Since the attentive observation of the nebulæ seems to show their change into stars, at epochs more or less remote, we must suppose from analogy that the existing stars and the sun himself were formerly masses of nebulous matter, reduced by condensation to the state in which we now see them. From this induction we are led to regard the sun, at the origin of things, as composed of a body more or less brilliant, surrounded by a vast atmosphere, which extended at first, by the effect of excessive heat, beyond the orbits of all the planets, and was confined successively by condensation to its actual limits.

"This atmosphere, which we may suppose possessed of a rotatory motion round its centre of gravity, whether this motion results from the reciprocal attraction of all its parts, or has been communicated to it primarily *—must, in condensing by cold, leave in the

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* Having accepted the theory of the condensation of all the stars out of Nebulæ, Laplace was quite entitled to *assume*, as he seems to have done, on the ground of the grand fundamental *fact* of our system, that the nebula from which it sprung must have rotated. The probable cause, as well as apparent proof of the existence of such rotations, had however been previously touched on by Sir William Herschel. In one paper he says:—

"The construction of these Nebulæ is certainly complicated and mysterious; and in our present state of knowledge it would be presumptuous to attempt an explanation of it. We can only form a few distant surmises, which, however, may lead to the following queries: — May not the faintness of the branches arise from a gradual diminution of the lengthened density of the nebulous matter contained in them, occasioned by its gravitation towards the nucleus into which it probably subsides? Are not these faint nebulous branches joining to a nucleus upon an immense scale somewhat like what the zodiacal light is to our Sun in miniature Does not the chevelure denote that perhaps some of the nebulous matter still remaining in the branches, before it subsides into the nucleus, begins to take a spherical form, and thus assumes the semblance of a plane of its equator zones of vapour composed of substances which required an intense degree of cold to return to a liquid or solid state. These zones must

faint chevelure, surrounding it in a concentric arrangement? And, if we may venture to extend these queries a little farther, will not the matter of these branches, in their gradual fall towards the nucleus, when discharging their substance into the chevelure, produce a kind of vortex or rotatory motion? Must not such an effect take place, unless we suppose, contrary to observation, that one branch is exactly like the other — that both are exactly in a line, passing through the centre of the nucleus, by way of causing exactly an equal stream of it from each branch to enter the chevelure at opposite sides: and this not being probable, do we not see some natural cause which may give a rotatory motion to a celestial body in its very formation." And again:—

"A circumstance which allies these very compressed Nebulæ to the character of many of our well-known celestial bodies, such as some of the planets and satellites, the Sun, and all periodical stars, is that very probably most, if not all of them, turn on their axis. Seven of the ten I have mentioned are not perfectly round, but a very little elliptical. Ought we not to ascribe the figure to the same cause which has flattened the polar diameter of the planets — namely, a rotatory motion? At the end of the twentieth article, I have already pointed out one configuration of the nebulous matter, of which the final condensation seems to be properly disposed for bringing on a rotatory motion of the nucleus; but, if we consider this matter —which, in its endeavour to come to the centre, will either dislodge some of the nebulosity which is already deposited, or slide upon it sideways—it will in both cases produce a circular motion; so that, in fact, we can hardly suppose a possibility of the production of a globular form, without a consequent revolution of nebulous matter."—VII. N.

have begun by circulating round the sun in the form of concentric rings, the most volatile molecules of which have formed the superior part, and the most condensed the inferior part. If all the nebulous molecules of which these rings are composed, had continued to cool without disuniting, they would have ended by forming a liquid or solid ring. But the regular constitution which all parts of the ring would require for that, and which they would have needed to preserve whilst cooling, would make this phenomenon extremely rare. Accordingly the solar system presents only one instance of this, that of the rings of Saturn. Generally the ring must have broken into several parts, which have continued to circulate round the sun, and with almost equal velocity, whilst at the same time, in consequence of their separation, they would acquire a rotatory motion round their respective centre of gravity; and as the molecules of the superior part of the ring, that is to say, those farthest from the centre of the sun, had necessarily an absolute velocity greater than the molecules of the inferior part which is nearest it, the rotatory motion, common to all the fragments, must always have been in the same direction as the orbitual motion.

"However, if after their division one of these fragments has been sufficiently superior to the others to unite them to it by its attraction, they will have formed only a mass of vapour, which by the continual friction of all its parts, must have assumed the form of a spheroid flattened at the poles and elongated in the direction of its equator. Here then are rings of vapour left by the successive retreats of the atmosphere of the sun, changed into so many planets in the condition of vapour circulating round the sun, and possessing a rotatory motion in the direction of their revolution. This must have been the most common case; but that in which the fragments of some ring would form several distinct planets possessing degrees of velocity, must also have taken place, and the four telescopic planets, Ceres, Juno, Pallas, and Vesta, discovered at the beginning of the present century, seem to present an instance of this; at least if it is not admitted with Olbers, that they are the fragments of a single planet, broken by a strong interior commotion. It is easy to imagine the successive changes produced by cooling on the planets whose formation has been just pointed out. Indeed, each of these planets, in the condition of vapour, is, in every respect, like one of the nebula in the first stage; they must, therefore, before arriving at a state of solidity, pass through all the stages of change we have just traced in the sun. At first, the condensation of their atmosphere will form round the centre of the planet, a body composed of layers of unequal density, the densest matter having, by its weight, approached the centre, and the most volatile reached the surface, as we see in a vessel different liquids ranged one above another, according to their specific gravity to arrive at a state of equilibrium. The atmosphere of each planet will, like that of the sun, leave behind it zones of vapour, which will form one or several secondary planets, circulating round the principal planet, as the moon does round the earth, and the satellites round Jupiter, Saturn, and Uranus, or else they will form, by cooling without dividing, a solid and continuous cycle, of which we have an instance in the ring of Saturn. In every case, the direction of the rotatory and orbitual motion of the satellites or the ring, will be the same as that of the rotatory motion of the planet; and this is completely confirmed by observation.

"The wonderful coincidence of all the planetary motions, a phenomenon which we cannot, without infringing the laws of probability, regard as merely the effect of chance, must then be the result even of the formation of the solar system in this ingenious hypothesis; we see also why the orbits of the planets and satellites are so little eccentric, and deviate so little from the plane of the solar equator. A perfect harmony between the density and temperature of their molecules in a state of vapour, would have rendered the orbits rigorously circular and made coincide with the plane of this equator: but this regularity could not exist in all parts of such large masses; there has resulted the slight eccentricities of the orbits of the planets and satellites, and their deviation from the plane of the solar equator.

"When in the zones abandoned by the Solar atmosphere, there are found molecules too volatile either to unite with each other or with the planets, they must continue to revolve round the sun, without offering any sensible resistance to the motions of the planetary bodies, either on account of their extreme rarity, or because their motion is effected in the same way as that of the bodies they encounter. These wandering molecules must thus present all the appearances of the zodiacal light.

"We have seen that the figure of the heavenly bodies was the necessary result of their fluidity at the beginning of time. The singular phenomenon presented by the rigorous equality indicated by observation, among the lesser motions of rotation and revolution of each satellite, an equality rendering the opposed hemisphere of the moon for ever invisible to us, is another obvious consequence of this hypothesis. Indeed, supposing that the slightest difference had existed between the mean motion of rotation and revolution of our satellite whilst it was in the state of vapour or of fluidity, the attraction of the earth would have elongated the lunar spheroid in the direction of its axis towards the earth. The same attraction would have tended to diminish insensibly the difference between the rotatory and orbitual motions of the moon, so as to confine to narrow limits a condition sufficient to cause the axis of its equator, directed towards the earth, to be subject only to a species of periodical balancing constituting the phenomenon of libration. If these oscillations are not now observed, it is because they have ceased to exist in consequence of the resistance they have encountered in the course of time, even as the oscillations of the terrestrial axis in the interior of the earth, arising from the initial state of motion, have been destroyed, and as indeed all the motions of the heavenly bodies have disappeared which have not had a permanent cause.

"The principal phenomena of the planetary system are therefore explained with great facility by the hypothesis we are examining; and these successive changes of a nebulous mass, and the leaving of a part of its substance by cooling, agree with all the leading phenomena, it must be allowed a high degree of probability. In this hypothesis, the formation of the planets would not have been simultaneous; they have been created successively at intervals of ages; the oldest are those which are farthest from the sun, and the satellites are of a more recent date than their respective planets. It may be, if we are ever permitted to reach so high, that by an examination of the constitution of each planet, we may go back to the epoch of its formation, and assign to each its place in the chronology of the universe. It is likewise seen that the velocity of the orbitual motion of each planet as it is now, must differ little from that of the rotatory motion of the sun, at the period when the planet was detached from its atmosphere. And as the rotatory motion is accelerated in proportion as the solar molecules are confined by cooling, so that the sum of the areas which they describe round the centre of gravity would remain always the same, it follows revolutionary motion must be so much more rapid as the planet is nearer the sun, as is seen by observation. It likewise results that the duration of the rotation either of the sun or of a planet, must be shorter than the duration of the nearest body which circulates round them; this observation is completely confirmed even in those cases where the difference between the duration of the two motions must be very slight. Thus the interior ring of Saturn being very close to the planet, the duration of its rotation must be almost equal, but a little longer than that of the planet. The observations of Herschel give indeed 0.432 as the duration of the rotation of the ring, and 0.427 as that of the planet; why then should we not admit that this ring has been formed by the condensation of the atmosphere of Saturn, which formerly extended to it? We may perhaps deduce from the laws of mechanics, and the actual dimensions of the sun, and the known duration of its rotation, the relation existing between the radius vector of its surface and the time of its rotation in the different stages of concentration through which it has passed. The third law of Kepler would be no longer the mere result of observation ; it would be directly deduced from the primordial laws of the heavenly bodies.

" In this system, as in that of Buffon, the particular form of the planets, the flattening at the poles, and bulging out at the equator, is only the necessary consequence of the laws of the equilibrium of fluids, and easily explains the greater part of the phenomena observed by geologists in the constitution of the terrestrial globe, which appear inexplicable, if it is not admitted that the earth and planets have been originally fluid.

" Let us now see what is the origin and part assigned to comets by this hypothesis. Laplace supposes that they do not belong to the planetary system, and he regards them as masses of vapour formed by the agglomeration of the luminous matter diffused in all parts of the universe, and wandering by chance in the various solar systems. Comets would thus be, in relation to the planetary system, what the aerolites are in relation to the earth, with which they seem to have no original connexion. When a comet approaches sufficiently near the regions of space occupied by our system, to enter into the sphere of the sun's influence, the attraction of that luminary, combined with the velocity acquired by the comet, causes it to describe an elliptic or hyperbolic orbit. But as the direction of this velocity is quite arbitrary, comets must move in every direction and in every part of the sky.

"The cometary orbits will, then, have every inclination to the ecliptic; and this hypothesis explains equally well the great eccentricity by which they are usually effected. Indeed, if the curves described by comets are ellipses, they must be greatly elongated, since their major axes are at least equal to the radius of the sphere of the sun's attraction; and we must consequently be able to see only those whose eccentricity is very great, and perihelion distance inconsiderable; all others, on account of their minuteness and distance, must always be invisible; unless, at least, the resistance of the ether, the attraction of the planets, or other unknown causes, diminish their perihelion distance, and bring them nearer the terrestrial orbit. The same circumstances may change the primitive orbits of some comets into ellipses, whose major axes are comparatively small; and this has probably happened to the periodical comets of 1759, 1819, and 1832. The laws of the curvilinear motion likewise show that the eccentricity of the orbit chiefly depends on the direction of the comet's motion on its entering the sphere of the sun's attraction; and as this motion is possible in every direction, there are no limits to the eccentricities of the orbits of comets.

"If, at the formation of the planets, some comets penetrated the atmospheres of the sun and planets, the resistance they met would gradually destroy their velocity; they would then fall on those bodies describing spirals, and their fall would have the effect of causing the planes of the orbits and equators of the planets to remove from the plane of the solar equator. It is therefore partly to this cause, and partly to those we have developed above, that the slight deviations we now perceive must be attributed.

"Such is a summary of the hypothesis of Laplace, on the origin of the solar system. This hypothesis explains, in the most satisfactory manner, the three most remarkable phenomena presented by the planetary motions.

"1st. The motion of the planets in the same direction, and nearly in the same plane.

"2d. The motion of the satellites in the same direction as their planets.

"3d. The singular coincidence in direction of the rotatory and orbitual motions of the planets and the sun, which in other systems would present inexplicable difficulties.

"The no less remarkable phenomena of the smallness of the eccentricities and inclinations of the planetary orbits are also a necessary consequence of it, whilst we see at the same time why the orbits of the comets depart from this general law, and may be very eccentric, and have any inclination whatever to the ecliptic. The flattening of the form of the planets, shown on the earth by the enlargement of degrees of the meridian, and by the regular increase of weight in going from the equator to the poles, is only the result of the attraction of their molecules whilst they were yet in a state of vapour, combined with the centrifugal force produced by the rotatory motion impressed on the fluid mass. In short, among the phenomena presented by the motions and the form of the heavenly bodies, there are none which cannot be explained with extreme facility by the successive condensation of the solar system; and the more this system is examined, the more we are led to acknowledge its probability.

"Undoubtedly, if, as Laplace has himself said, a hypothesis not founded on observation or calculation must always be presented with extreme diffidence, this, it will be granted, acquires, at least by the union and agreement of so many different facts, all the marks of probability. But what, in my opinion, principally distinguishes it from the ordinary theories concerning the formation of systems, is the identity which it establishes between the solar system and the stars spread so profusely through the sky.

"All the phenomena of nature are connected, all flow from a few simple and general laws, and the task of the man of genius consists in discovering those secret connexions, those unknown relations, which connect the phenomena which appear to the vulgar to have no analogy. In going from a phenomenon of which the primitive law is easily perceived, to another in which particular circumstances complicate it so as to conceal it from us, he sees them all flowing from the same source, and the secret of nature becomes his possession. Thus the laws of the elliptic motion of the planets led Newton to the great principle of universal gravitation, which he would have sought for in vain in the less simple phenomena of the rotatory motion of the earth, or the flux and reflux of the sea. But, this great principle being once discovered, all the circumstances of the planetary motions were explained, even in their minutest details, and the stability of the solar system was itself only the necessary consequence of its conformation, without which, as Newton thought, God would be constantly obliged to retouch his work, in order to render it secure. Laplace, extending to all the stars, and consequently to the sun, the mode of condensation by which the nebulæ are changed into stars, has connected the origin of the planetary system with the primordial laws of motion, without recurring to any hypothesis but that of attraction. He has, therefore, extended the great law of universal gravitation, which is probably the only efficient principle of the creation of the physical world, as it is of its preservation.

"The hypothesis of Buffon required not only the fall on the sun of a comet as large as the mass of all the planets and satellites, which is very improbable, but in order to explain the formation of the innumerable planetary systems which the imagination may conceive round each star, as round the sun, it would have been necessary to imagine the fall of so many new comets, that reason would soon refuse to believe in chances so often repeated, and always when there was need of them. The principle of the condensation of the atmospheres of the nebulæ is, on the contrary, general, and would produce phenomena nearly analogous, on all the stars and planets.

"If the ideas of Laplace on the origin of the world have not yet acquired that degree of certainty which the support of calculation and observation can alone give, and without which the finest systems are as yet only brilliant conjectures, let it be remembered, that the theory of attraction had been conjectured by Kepler long before Newton had proved its mathematical truth. Let us look back, let us view the point from which we have set out, and not despair of the efforts of the human mind. Perhaps it is reserved for our age to fulfil that prediction of a philosopher of antiquity, 'The time will come when the most profound secrets of nature will be revealed; and posterity will marvel that so simple an explanation of these great phenomena lay hidden so long.'" — *Seneca*, *Natural Questions*, book vii.

CHAPTER III.

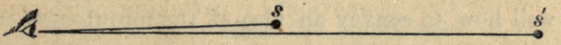
THE VITALITY OF THE SIDEREAL UNIVERSE, CONSIDERED AS A SCHEME OF GALAXIES.—RELATION OF THESE GREAT FORMS TO TIME AND TO THE INFINITE.

While describing, in our first chapter, the extension of these grand Sidereal Clusters through Space, I hinted, as the only mode by which their extraordinary forms can become intelligible to the human mind, that they are connected with equal profundities in Time, and stand forth to us now, as mere fragments or elements of a series, which may, in its entireness, be at once simple and complete. Unsupported by actual manifestations of such changes, this view is clearly nothing more than a conjecture; nor ought it to be received unless as a very vague guess, if we cannot discover indisputable evidence of the Mutability of these groups, if not of their Mutations. Of course, my inquiries must now be confined to the aspects of our own galaxy, which, however, in every leading feature, may be accepted as a type of its Cognates.

I.

Intimations inconsistent with the supposed quiescence of our celestial vault, have, almost from the commencement of recorded observation, been unfolded before mankind; but inasmuch as the periods occupied by so high mutations, are not measurable by that lifetime of the human race which, in all epochs of imperfect knowledge, constitutes man's *for ever;* those singular changes involving even the apparition and disappearance of stars, were reckoned only as monstrous disturbances, and apart from order:—nor was systematic activity, comprehensive of the largest revolutions, recognised as the essential principle of celestial mechanisms, until the latter half of the bygone century. The merit of first discerning and stating the argument, which conducted us to the true system of the heavens, is unquestionably due to the ingenious Mitchel; and it struck him on his contemplating the Pleiades. Taking that beautiful group, in the first place, as if painted on the *surface* of the concave, it seems to manifest an interruption of the law of the equable distribution of the stars, and thus claims for itself a certain distinct individuality; nor, as MITCHEL perceived, is this character withdrawn from it by supposing that it consists of stars not actually grouped *on the same surface*, but only nearly *in a line*, and probably far from each other, amid the recesses of space. On the same principle of equal or indifferent scattering, the occurrence of so numerous a group so close in the same line from the eye, is wholly improbable; so that the fact is forced on us, that we have here a *peculiar systematic arrangement*,—a group of stars, in fact, within our galaxy, closely linked together, and, as Mitchel ventured to conceive, possibly manifesting that connexion, by partaking of common and great schemes of motion. Those ideas could lead to no positive result at the time they were proposed. Considering the remoteness of the Pleiades, and the magnitude of the orbits with which we must endow its individual stars, no motion by which they could be affected would have been discernible by instruments which then existed: and it was reserved for Herschel, in more auspicious times, not only to reproduce the argument with new force and efficiency, but, on sustaining its conclusions by facts, to constitute the grandest era in modern Astronomy.

Herschel was led to his capital discovery by the peculiarities of the DOUBLE STARS. These are *binary groups*, much more remarkable in regard of the proximity of their constituents, than the Pleiades. To the naked eye, they seem only one star, and the aid of the telescope is necessary to divide them. Now, it is possible that this proximity is apparent only,—that the fact of one star lying, as below, in a line almost right behind another, is the entire significance of the phenomenon:—but if this were so, the comparative frequency of the occurrence could be computed, and the consistency of the hypothesis with the principle of the random or indifferent scattering of these orbs—that is, the principle of *their independence of each other*—easily and accurately tested. Now, the multitude of such binary combinations discernible in every sphere of the Heavens, is at entire variance with such an explanation. With



respect, for instance, to one class, or order of Stars, while the probable *optical* combinations are *forty-eight*, the observed combinations are *six hundred and fifty-three*, leaving *six hundred and five* SYSTEMS, or combinations of two stars, in that portion of space, not accounted for by the supposed universality of equal scattering, or of the mutual independence of these orbs.* Like his predecessor, Herschel was thus forced on the truth, that these phenomena really betoken speciality, or that they are *schemes* of TWIN SUNS: but, far more fortunate than Mitchel, he had touched on times when the verification of his guess could be proposed without hopelessness or hesitation; and by his own labours first, its reality was for ever established. I know not well how to convey an idea of the minuteness of the spaces that are now measurable by Instruments, although a clear understanding on this point seems necessary, that my readers may confide in our discoveries regarding the double Stars. Since the times of the famous Ramsden, the art of graduation, and, in general, of the construction of instruments adapted to the most difficult work, has advanced rapidly towards a perfection previously unhoped for; nor can I conceive any increase of stability, symmetry, or delicacy, in the exquisite structures now produced by Repshold of Hamburgh, and Ertel — the worthy successor of Reichenbach at Munich. A circle in my possession, by the last named eminent artist, having a diameter of only 3¼ feet, is divided into 10,800 equal parts; nay, each of these infinitesimal spaces it is possible to divide again by its accompanying micrometrical apparatus into 1200 subordinate intervals! It is surely no marvel, then, that small motions can now be discerned in the skies, and the smallest spaces through which a star passes, in obedience to its destiny, charted and critically discussed. Mystery was accordingly very soon removed from the significance of the double stars. SYSTEMS they unquestionably are, with peculiar internal harmonies; — systems realizing the idea of suns connected in orbits, not precisely as the planets encircling one large luminary, but where each constituent revolves around an intermediate point or a fixed centre. The Heavens are positively thronged with these remarkable associations; and perhaps their most singular feature is, that the curves through which they move, show, by their special characteristics, that the very law or principle of order unfolded by the structure of our solar system, and whose discovery constitutes the imperishable glory of SIR ISAAC NEWTON, is that which also prevails there, — governing as rigorously as it does the revolutions of our small Moon, even such mighty destinies.

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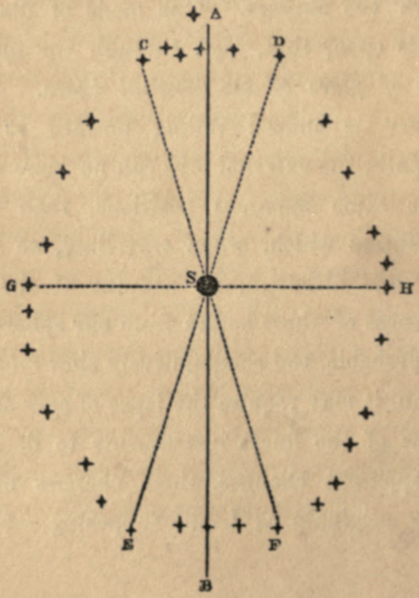
* I have again to refer to my volume on the "Architecture of the Heavens," where this subject is discussed with a detail unnecessary here.

Closer inspection of the contents of the Heavens speedily evinced that these binary groupings are only the simplest instances of an ordinance which, probably, sways our entire scheme of Stars; and has enabled us to discern a range of self-contained systems of being, rising in grandeur and complexity, until we reach combinations even magnificent as those which arrested the thoughts of Mitchel. There are many instances of ternary or triple Stars wherein motion and system have been definitively ascertained to exist. A fourfold group, in Lyra, the connexion of whose parts is also beyond a doubt, conducts us a step still higher; and we are constrained to apply the same interpretation to collocations yet more multiplex. The three bright Stars in the belt of Orion cannot owe their existing neighbourhood to the law of equal scattering. The Præsepe in Cancer, so studded with internal duplex systems, is also, without doubt, a group whose constituents have the closest sympathies with each other: so likewise with groups in Lyra and Taurus: and, in regard of the Pleiades, the probability of their merely optical connexion is measured by the almost evanescent fraction, $\frac{1}{4409 \times 10^{50}}$! Ascending to schemes yet more gorgeous, look at the dazzling spot in Perseus, or even at one of those still larger masses in the Milky Way, whose structure so clearly indicates a distinct individuality! But, unsatisfied with a knowledge of the mere existence of such motions, we demand, with no unwarrantable eagerness, an insight among their august *periods*; and the reply to this inquiry only the more stirs our wonder. A few of the double Stars have brief revolutions: a Star in Hercules, for instance, having an epoch of only about fourteen years: the period of η Coronæ, a well established Star, is forty-three years; that of ξ Ursa is fifty-eight years; the period of the two Stars in Castor, as deduced from the courses they have run, is two hundred and fifty-three years; while that of γ Virginis, probably exceeds six hundred. Induction, however, reveals epochs still mightier than these: the unit, for instance, of time with Mirza and Alcor cannot be less than one hundred and ninety thousand years; while the double systems which constitute the fourfold group in Lyra, will not complete the circuit of their combined revolutions in less than one thousand of our World's centuries! But since even the greatest of these, are arrangements limited to small specks in space — how shall we compute the periods through which the three Stars in the belt of Orion must evolve their courses, and, by passing from their present symmetry, present that stately Constellation in the various aspects it must, in the course of the dread past, have assumed: — how shall we speak of the group of the Pleiades ever and anon as the ages roll shining towards other Worlds, in new configurations; or of the spot in Perseus, or of the masses of the Milky Way, modifying so solemnly their still and, apparently, everlasting forms! Nor is it merely through the fact, that one star changes its position in relation to another, that the entire augustness of these evolutions becomes apparent. Their circuits, like that of our own Globe around the Sun, are doubtless the units of cycles of countless inferior changes. Birth, youth, manhood, death, and resolution into novel forms, accompany inseparably our Earth's mystic course; and, as the units of this varied annual life are heaped up, ever and anon the phenomena they include, enlarge and evolve—dynasty succeeding dynasty with faculties steadily increasing, race ever rising on the ruins of race, and reckoning its predecessors as the dust:—what thoughts then must crowd on us when gazing on the Heavens, containing within their still and silent majesty, even those stupendous and correspondingly prolific cycles!

II.

The character of the clusters within our galaxy, however, points to a fact far more interesting and farther reaching than that they are self-contained systems. Raising our thoughts to the whole Stellar Universe, what are those grand groups lying apart in space, save special clusters, with as clear an apparent *individuality* in respect of the *entire creation*, as these minor forms possess in reference to our own astral scheme? Is it not likely, therefore, that what we have learnt concerning the smaller groups, may also characterize those clusters of a higher order? that, just as with the fourfold star in Lyra, or probably the assemblage of the Pleiades, even the dazzling mass in Hercules, or that more irregular one in Plate IV., or even that other mysterious scroll, (Plate VI.,) are also united into separate schemes internally consistent and upheld by their inherent activities? The question is too wide to admit of a decisive answer; but some light may even here be attained from observation on what is passing around us.

The Double Stars, compared with the masses of Orbs in the Heavens, are few. Our Sun, for instance, has no companion, but exists like multitudes of others apparently alone. Now, if our peculiar scheme, as a cluster of the first order, is throughout characterized by *activity*, we should discern motion amongst these solitary orbs, and especially in the case of the Sun. But if the Sun moves, how are we to descry his changes? Not by sensation, not by direct observation on himself; for we would necessarily pass along, without jerk or disturbance on through the abysses. One mode of discovery alone is open, that, viz., through the *apparent change of place of the external Stars.* If our luminary is indeed rolling onward in some great path, the external orbs can no more remain in the same apparent positions, than terrestrial objects which, when travelling, we swiftly pass; and although, on account of the great remoteness of these bodies from our sphere, and, as is probable, the comparatively slow motion of the Sun, it may require the lapse of ages and the exercise of the finest instruments to determine their apparent changes, these changes must — if they originate as I am supposing —all tell one tale, and when discerned even roughly, point, by their direction and general characteristics, to that grand motion which is their cause. It was the rude view only which induced Sir William Herschel to announce his early conclusions on this subject; which subsequent, more full and accurate inquiry has thoroughly confirmed, viz., *that the Sun with his Planets, is rapidly darting towards a point in the direction of the constellation Hercules.* Suppose that in the subjoined wood-cut, the Sun's path is represented by the line A B,



it is clear that our first intimation of that motion would be the apparent widening of the distances of the Stars lying in the region A, towards which we are travelling, and the corresponding closing in of the Stars about B, — a phenomenon apparent in the changes established by authentic catalogues previous to Herschel's time: but it is equally undoubted, that displacements of position of corresponding significance, ought to be found *with regard to all the surrounding orbs;* and especially that the swiftest apparent motion should characterize those *in the positions at G and H.* Now, in recent times, ARGELANDER of Bonn has discussed the subject with an accuracy that leaves nothing to be desired ; and the truth is firmly established, that we must accept the motion of translation of our Sun. The speculative views of this Astronomer — that our orb is rolling around some grand central body, as he thinks *opaque*, situated near the bright stop in Perseus, are certainly questionable; but it is undoubted that its motion is in the *plane of the Milky Way*, where the preponderating attractive or centralizing power of our galaxy is naturally located. Not only do the general apparent displacements of the Stars uphold this conclusion; but what is still *residual* with regard to these motions, seems to bestow on them all grand orbits, reconcilable in so far with Argelander's general views; so that our bed of Stars no longer shines before the apprehension as a fixed and completed stratum, but rather as one mass of unresting activities, working out, as Time rolls on, its stupendous destinies. Overwhelming indeed the conceptions which this unlooked-for discovery has brought clearly into light! The internal and compact harmony of our own planetery system has now been long a common truth, so that LA PLACE could speak, without apparent hyperbole, of the orbit of a drop of spray driven across a cataract being as fixed and intelligible as the course of the majestic Jupiter; but as we now see those Heavens, they tell of the diffusion of such sympathies, even through the unfathomable expanses of the Firmament, so that the minutest grain of sand on our sea shore, lies, in virtue of its mere existence, in necessary union with the remote masses in the Milky Way! It was said of old that MATTER is DEAD! What then is LIFE? The rotting leaf cannot change its form and position—not an atom of it can pass from one part of space to another, without telling, if these facts be true, even to the remotest Star, the alteration of its character and elements, and begetting, in so far as it is concerned, new movements in the history of the Universe!

In regard of inquiries so vast, perhaps we should expect no more than an intimation of the *reality* of such motions. But we can go a step still onward. The Solar motion, if undefined in reference to the nature of its vast curve, can yet be approximately valued, in regard of absolute amount. The question of the parallax of the fixed stars, or of our power of measuring spaces sufficiently evanescent to determine the distance of these stars from our Solar Sphere, is irresolvable no longer. Twice, at least, has it been distinctly answered, and by two men of no uncongenial habit of mind, over whose loss Science had recently to grieve: one the illustrious BESSEL, with whose fame Europe is filled, and my lamented countryman THOMAS HENDERSON. Unquestionably to this latter astronomer belongs the glory of planting the first milestone amid the external spaces; and — speaking in reverence, though in unison with the imperfect desires of Man — it may surely be deplored that, unlike the case of the immortal German, the life of the discoverer was closed, not indeed in the beginning of his usefulness, but in the very spring-time of a fame adequate to his great deserts. The case of one of these stars, and probably the best defined, will suit us now. It is BESSEL'S — 61 *Cygni.* The circumstances are briefly these: — the remoteness of this Star from our Planetary Sphere, is definitely about 670,000 times our distance from the Sun; and we have accurately determined its apparent motion through space. Its distance from the point of observation being known, that apparent *angular* motion can be converted into an apparent *motion of so many miles;* just as a traveller could tell, should a remote object appear to be in motion—if he knew the interval dividing him from it — the exact amount of its displacement. Now, if this displacement of 61 Cygni is owing, as it is, in all likelihood, not to its proper motion, but to the translation of the Sun, we may clearly infer, on the simple principle above stated, with what velocity we are darting through space. In Bessel's opinion, we may move in this immense orbit thrice as fast as the Earth travels in its Planetary Ellipse; or with a speed so swift, that we might reach 61 Cygni in 41,000 years. Now, large though this period is, there is nothing in it whatever to overwhelm our imagination. If Geology is not the veriest fable, if we are not to return to the old conceptions, that the rocks of our world's crust, with their entombed creatures, have been laid down there purposely as the most mocking of enigmas—an enigma that seems to have a meaning and yet has none—even this great course of years is only a very brief point amid the latest changes affecting the surface of the Earth. Free, then, from fear, let us rise far higher; and, assuming that Bessel's Star indicates the average distance of the nearest Orbs, we infer that the Sun would require no more than five hundred thousand years to reach that extremest verge at which the eye can descry a single Star; nay, it could reach that remotest distance to which Lord Rosse's Telescope can pierce, in about TWO HUNDRED AND FIFTY MILLIONS OF YEARS; and so far is even this stupendous period from sounding all the working time of Nature, that many of the mountains of our Earth may, through its whole duration, have been in being, rearing their peaks towards different constellations, and surviving, in their littleness and fragility, even these immense transitions![*] The numbers I have quoted are indeed only approximate; but, in rendering conceivable a subject so vast and vague, they have, notwithstanding their necessary inaccuracy, an important use. Under their direct announcements, the stability of our supposed Universe wholly disappears. The stars that shine over us now may indeed be those that arrested the ardent gaze of the Chaldæans; but at depths of time by no means beyond our reach, we must have passed through many arrangements of Orbs; and if, as assuredly they do, these Stars move like the Sun, our majestic Cluster may not now, in any part, have even a similitude of what it was! How stupendous such ceaseless evolutions! How overwhelming the thought, that what, above all things, seemed the fitting emblem of the Eternal, is thus almost visibly subject to Transiency; even in its most august and awful forms, only one phase of the fleeting and phantasmal! Often overpowered by the dread contemplation; beneath such majesties feeling, as in faintness, that surely I must be lone and forlorn, I turn ever with a cheering delight to that sweet home-picture of LUTHER's, when he speaks of the little bird that, on summer's evenings, came to his pear-tree at sunset, and sang, ever melodiously and without one note of misgiving, because, though dread Eternity was above, below, and around it, GOD was there also!

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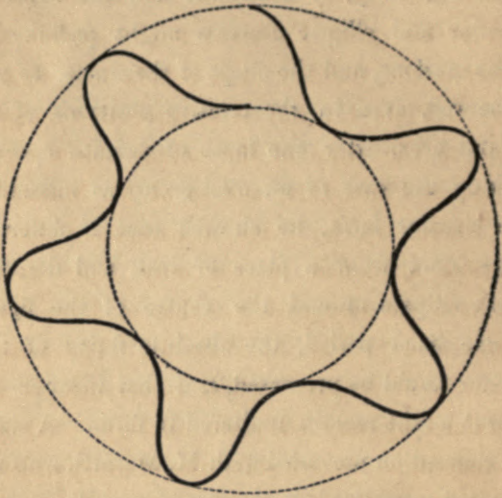
[*] If numbers so vast continue to overpower the imagination, let it be remembered that—as I have shown near the conclusion of our first Chapter—Lord Rosse's largest telescope may, at this very moment, positively look backwards through time by the space of *thirty millions of years*; and that one as much larger than it as it exceeds Sir John Herschel's, would tell of firmaments as they surely existed at an epoch of the Past half as profoundly removed from us as is indicated by the previous enormous number!

III.

I feel entitled, by the analogy of all internal groups, and by the facts which bear so directly on the state of our entire galaxy, to assume, as the law of the existence of Stellar clusters — *a pervading interior activity.* What, then, is the meaning of this activity? — what portends it in regard of the history and fates of these stupendous groups of stars? Again, I must warn the reader that we are walking in the twilight, and that our conclusions rest, perhaps often, on only faint analogies. Several points, however, press for consideration.

1. It was not unnatural that the first speculations on this lofty subject, should adopt as their foundation the idea of the *absolute permanency* of the existing forms of the Stellar groups; the more especially as, previous to the use of Lord Rosse's great mirror, those shapes had frequently an aspect of singular simplicity, and

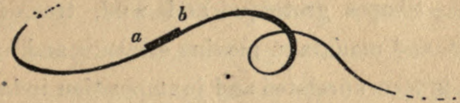
therefore of apparent completeness. This manner of contemplating them, seems to have swayed Sir John Herschel, when he endeavoured, with his usual ingenuity, to determine how the stars of circular and elliptic clusters might partake of great motions, and the shape of the cluster be yet preserved, even in the relative positions of its several orbs, after the lapse of definite epochs. Taking the case of an oval group as including the circular form, he showed that if different stars start from a place of rest, and describe great ellipses around the centre of the figure in one fixed period, the absolute fixity of the cluster would be preserved, and that through all ages it might remain unaltered in form. A similar conception prevailed with M. Mosotti, who attempted to realize it in the case of annular groups, which, like that of Lyra, as previously known to us, (Fig. 4, Plate I.) exhibited a simple and regular outline. The stars in such a ring would be permanently attracted to the middle of the ring; so that a Star moving from one side of it would have its velocity increased until it reached the centre, which, owing to this acquired velocity, it would pass and move onwards, until it arrived at the other side. Supposing then that the stars had a forward motion also, they would assume a waving course like that below; and in that case, unquestionably the ring would continue in



space, and preserve, through the course of duration, its existing proportions. One valuable and pleasing result, may be traced to speculations like these. They show that, even with our imperfect appreciation of schemes of mechanism so immense and complex, we still may rise to the conception how harmony can endure through very varied evolutions, and their fates be unrolled, without collision or jar.

2. The schemes spoken of above, however, do not exist in Nature, and cannot shadow forth the destinies of the Universe. Sir John Herschel's idea (which does not rise to the elevation of his great Father's) might explain and preserve the stability of a nebula like that of Fig. 2, Plate I.; but it is altogether inapplicable to the state of the actual object represented in Plate III.: and so of M. Mosotti's; for where can he lodge a permanent line of greatest attraction in the only Ring nebula we have yet seen clearly—that of Lyra itself, represented in Fig. 5, Plate I.? The notion, however, of steady cyclical recurrence, is not sustained by any adequate analogy. Around us, indeed, we discern stabilities of every order of duration; but it is *stability* only, not *absolute permanence;* for as our vision enlarges, every system which first seemed final and complete, inevitably resolves itself into a step or phaze of a still loftier progress. How emphatically is such progress indicated by the state of central concentration of the more globular clusters, which are not now even as Herschel saw them, but pass through the whole series of Nebulous Stars up almost to a final state! But, to borrow an illustra-

tion from phenomena far less overwhelming, observe the Earth as it wheels around the Sun, moving quietly through its courses of seasons, and unfolding, as their accompaniments, its succession of life and death. If aught of the larger appearances, open to our immediate inspection, could seem stable, surely it is *that:* for, as it rolls on, the Sun shines on it through every year the same; and affects it with the same varieties of Light and Heat. Yet note its interior history! no regular cycles are there, but a mysterious growth and evolution of Races, insomuch that, at different epochs, our World has been fancied to have become new. Nor can its orbit be termed permanent. It belongs to that part of the mechanism of our Planetary system, which has provision for the longest life. It is connected with that portion of it which seemed, at first sight, framed to rise above every perturbation, and to pass through the Ages, stamped with capability for Eternity: but a COMET unexpectedly broke in on the attractive vision, and informed Astronomers of an ETHER through whose minute but persistent influence all these arrangements must close. Laws, great or small, in so far as we have seen the Universe, ever merge into larger ones, which, by involving do not destroy the smaller, but only summon them to conspire towards mightier objects or, to place my thought in a graphic form, the absolute path of the Car of Being is along some complex curve, definable through all its



windings,—but Man, because his experience is drawn only from the smallest portion of its course, believes, too often, that the line is straight—seeing neither its anterior nor posterior convolutions.

3. If, then, we are precluded, by the apparent shapes of the groups composing the Sidereal Universe, as well as by the analogy of all known processes of Nature, from conceiving that their immense activities are only destined, through harmonious cyclical revolutions, to sustain their forms in absolute permanence; we have no choice but recur to our first idea, that these grand Clusters are, in their existing conditions, only as steps or phases, in a SERIES OF CHANGES, which their internal ener-

gies evolve. No wonder, if this is so, that their shapes have the aspect of being capricious! We stand towards them exactly as we would to our own Earth, if the sum of our perceptions regarding it were drawn from a glance during a momentary opening of the eye, which then shut again for ever. Shapes grotesque and wild, tree, field, house, and mountain, moving creature, and naked rock, in form unrelated and juxtaposition inducing every where bewilderment,—such, in that case, would constitute our knowledge of a World instinct with fusing and enlarging harmonies. But different, how unspeakably, the reality! That SPIRAL NEBULA, or our own irregular MILKY WAY; nay, even the unfathomed mysteries of the spot in ORION, confuse and startle us no more by the display of their sparse and unaccountable patches of stars. The mind, ascending aloft, and passing from the idea of stability, conceives now of all these mighty forms as partakers of a change as restless as the events that grow up, and fade, and pass away around it; and it darts through durations that have gone, and again onwards into the future, in eager but reverential effort to discern the nature of that SERIES, or stupendous SUCCESSION, which through its own completeness can bestow harmony and clear significance even on elements so perplexing and strange. And truly it is not in vain, or only for trifling objects, that thus we struggle, in all its attainable majesty, to evoke the IDEA of TIME. The presence of these gigantic periods, replete with mighty works, is no mere fantasy to amuse, nor simply overpowering like a heavy or affrightening dream. The Universe, stretched out along its co-ordinates, Space and Duration, calls forth, even as with trumpet-voice, the action of those Faculties, which alone can sustain Man amid such Immensities, by uniting him with the ABSOLUTE. By FAITH we live now, even as the Patriarchs: and Science, at the extremity of its evolutions, thus touches on a farther Land, pointing across the frontiers of its flickering Realms of Change, to the calm but lustrous region of the Unchangeable.

IV.

I shall adventure no farther amid these Infinitudes. Not mocking the human Imagination, I shall not aim to conduct it towards still loftier elevations, even to a view of that mass of Clusters as a whole, in which each individual has arisen, and now holds its place and being, because it belongs to some stupendous career; but, withdrawing from heights far too dizzy for the stablest Reason, I shall conclude, by touching on a question of profoundest interest to Humanity. Looking at these mighty Motions, filling Space, and apparently sustaining that dazzling Universe in its course through the depths of Time, the inquiry becomes irresistible — What are the FORCES which shape and sustain these changes?—not, I mean, the mere technical definition of these Forces, but what is their relation to the DIVINE MIND? I assume it, of course, as indubitable — not only as certain in itself, but as a position which nowhere can now be doubted, that these Forces are only the obedient creatures and ministers of the EVERLASTING—Powers summoned into being by His will, and fashioned to carry out His unsearchable decrees. But my question goes deeper than this. What is force in itself? When we speak of a Force of Gravitation, for instance, what mean we? Does any distinct idea belong to the word, or is it only deceptive and confusing? THERE IS NO FORCE PERCEPTIBLE IN NATURE. Analyze as we will, there is not a trace even of a subordinate or delegated Power as the guide of material Mutations. Nothing in the history or condition of the Universe — whether extended through Space or Time, can be discerned, beyond ORDERLY SUCCESSION. One event follows another; and has done so: — this is the sum of our intelligence from the Phenomena of Matter. But knowledge so meagre, cannot satisfy us. That grand display of sequence must surely have a life within it, and a condition different from mere orderly collocation: between one event and another, as the substratum of their concurrence, the Mind demands a CAUSE. That cause is not *discernible*, and therefore not *representable*; but I am assured, by the strongest intuitions of my being, that it exists. I must seek it then in the region of the UNREPRESENTABLE — among realities independent of Time and Space. Now, I know no cognate idea unless that of WILL. Power or Force has no analogon in my mind, except a FREE ACT; and therefore, as the link of every term of the infinite successions of the Material Universe, I descry even the IMMANENCE of its GREAT GOD! Law is not merely the Almighty's minister: the order of the world is not merely His ordinance: the Forces, if so we name them, which express order, are not powers or inferior energies He has evoked from the Silences, and to whose guardianship he has intrusted all things, that so he himself might repose. No! above, below, and around, *there* is GOD, *there* his dread Omnipresence, speaking to Finite Creatures through finite forms, a language, which only the Living Heart can understand! In the rain and sunshine, in the soft zephyr, in the cloud the torrent and the thunder, in the bursting blossom and the fading branch, in the returning seasons and the rolling star—there is the INFINITE ESSENCE, and the mystic development of His WILL!

NOTES TO PART I.

NOTE A.

CALCULATIONS REGARDING THE PROFUNDITIES OF THE STARS.

The computations in the First Chapter, relative to the profundities of several stellar objects, as measured by the velocity of light, considerably differ from what is usually stated on this subject. The numbers generally employed, assume, as a basis, that the parallax of stars of the first magnitude, is *one second* of space; a basis notoriously untrue, inasmuch as several of them that have been very accurately examined, certainly do not exhibit a fifth of a second of parallax. I have taken the distance of Bessel's star, 61 Cygni, as probably the mean distance of these orbs,—although well aware that no such assumption can be supposed free of error. The approximate result of this is, that light would consume more than ten years in travelling towards us from the sphere of these brighter stars; and all the other numbers I have used grow out of this period as their basis

NOTE B.

FACTS REGARDING THE SIDEREAL UNIVERSE, NOT YET CONSOLIDATED INTO A SYSTEM. — THE PHENOMENA OF THE VARIABLE STARS. — THE UNEXPLAINED PARTS OF OUR SOLAR SYSTEM; COMETS; THE ZODIACAL LIGHT, AND STREAMS OF METEORS; THE INTERPLANETARY ETHER.

THERE are several phenomena, of striking aspect, and doubtless of high import, connected with the sidereal universe and our own system, to which, in the absence of direct and clear evidence as to their character, we were inclined to give that signification most in accordance with the nebular hypothesis, but which —now that the substructure of Fact has been withdrawn from that hypothesis—must again be contemplated apart from all theory. The modifications thus necessarily impressed on our views of the chief of these, I propose to explain in this note.

I.—THE VARIABLE STARS.

This singular phenomenon, affecting many of the stars visibly, and probably a great number more by a less degree, consists in a periodical variation of their light,—the bodies changing their apparent magnitudes within a certain period of time. The following list contains the chief facts that have been ascertained :—

Name of Stars.	Duration of variation in days.	Extreme Magnitudes.	
		Max.	Min.
Algol, ...	2.87	2.3	4
δ Cephei, . . .	5·37	4.3	5.4
η Aquilæ, . . .	7.18	4.3	5.4
β Lyræ, ...	12.91	3.4	4.5
α Hydræ, . . .	55.—?	2.–	2.3
Star in Sobieski, .	60.39	5.–	7.–
α Cassiopeiæ, .	79.03	2.–	3.2
α Herculis, . .	95.—	3	4.3
Star in Virgo, . .	145.43	6.	—
α Orionis, . . .	199.—	1.–	1.2
Star in Leo, . .	311.4	5.6	—
ο Ceti, ...	332.04	2.–	—
Star in Crown, .	335.—	6.–	—
... the Serpent, .	359.—	6.7	—
Do. .	366	8.–	—
Star in Ophiucus, .	389	7.–	—
χ Cygni, . . .	406.06	5.–	—
30 Hydræ, . . .	493.86	4.–	—

The periods given above, as well as the amount of variations, are the mean or average ones, — not the average of observations merely, supposing these to vary through unavoidable error, but of actual variations in the phenomena. In several cases, the changes in the star differ from its specified mean or average, by two magnitudes, and, in time, by a tenth of the whole period. Neither must it be supposed that the change is regular — the star passing from its least to its greatest light, by marked gradations; for, while one law seems to prevail with them all, viz., that they pass from their epoch of least light to that of their greatest, in considerably less time than from their greatest to their least, they are all subject to minor irregularities, which are infinitely perplexing. With regard, for instance, to Algol, whose period, at present, is exactly 2 days, 20 hours, 48 minutes, 58 seconds, we have reason to believe that, in former times, the variation occupied a somewhat longer duration. During the greater part of this period the star is unchanged, and of a *weak* second magnitude. When it begins to decrease, it sinks down, in between three and four hours, to the fourth magnitude, remaining in this state about a quarter of an hour; and then increases again to the second magnitude, in between three and four hours— changing its brightness very rapidly (according to ARAGO) as it passes through the third magnitude. The Star β Lyræ, whose period is thirteen days, exhibits variations still more puzzling, but which seem by no means peculiar to it. For instance, it has two maxima and two minima in each period — attaining, in both maxima, about the same magnitude of 3.4; but in the one minimum sinking to 4.5, while in the other it does not go below 4.3.

No explanation hitherto proposed can be received as accounting, satisfactorily, for these phenomena. It has been said, that these stars may be *discs* and not spheres, and that they now present their faces, and again their sides, or edges, to the earth; but the idea wholly contradicts any possible operation of the law of gravity. Secondly, we have had the supposition of dark planets revolving around them and intercepting part of their light; but this would require planets so large, that the stars themselves would not balance them; but must have *visible* motions of their own around the centre of gravity of their system,—so as, in fact, to appear as *double stars*; their attendant only being *opaque*, as Bessel has recently supposed with regard to Sirius and Procyon.—The third explanation is, that they rotate on their axes, and present to us alternately dark and bright sides. Now, although—so long as the aspects of the Nebulæ taught us to conceive that rotation may belong essentially to all stellar formations—we might be inclined to overlook minor objections, it is undoubted, since we are obliged to seek the explanation of the phenomenon from itself alone, that we are not in a position to reconcile its phases with this notion. The strange starts in the variation of the light, above enumerated, can scarcely be reconciled with any thing that rotation would produce; but what is of much more moment as an objection, is the apparent variation of the *period* of rotation, —as this character of all orbs we know, is unquestionably the most steadfast. I agree with Argelander of Bonn, that, looking at these singular facts in an isolated manner, the time has not come in which we should prepare to frame a theory. The minute changes characterizing them have been too little studied and discussed. If even one star—Algol, for instance—had been so sedulously followed in its variations, that we could draw out a curve of Light corresponding even to five minutes interval during its period, a ground would be laid on which conjectures might be founded. Most cordially do I join in the wishes and aspirations of this excellent observer,—"If we desire to discover what those powers are which announce themselves from immeasurable distances, in a manner so peculiar, we must first ascertain what words they address to the Earth in their own emphatic language. I think it likely that this phenomenon, so little noticed, and still so much unknown, is one of very wide significance—probably indicating some conditions under which all the stars hold their existence; and assuredly, standing as we do, the rejoicing inheritors of the toils of ages in other fields of this rich domain—gratefully contemplating, in our rich and wondrous acquirements, the results of the labours of Hipparchus and Ptolemy, of Copernicus and Gallileo, of Kepler, Newton, Herschel, and Laplace — it is not ours to be deterred from the attempt to begin, or to advance even slightly, a new branch of knowledge, merely because we cannot finish it, but must leave our imperfect thoughts to be enlarged and corrected, and to become fixed science in another age. At present, let us gather well the facts respecting these most puzzling variable stars; and for them too there will one day arise a Copernicus and a Kepler; and a Newton will not be wanting once more to show forth that here also, amidst seeming confusion, simplicity reigns. It may appear bold to entertain such hopes, whilst we are only beginning to unravel what is so full of complexity; but I avow them in the consciousness of the capacity of the human Mind exerting its indwelling power to investigate the true and Eternal; — I avow them in confidence in the energy of that active striving after knowledge which is now evinced in every region of the Unknown. Yes! let the Inquirer move on! Every step forward brings us nearer the end; and if we cannot reach it, at least may Posterity not reproach us with being inactive, and having neglected to prepare for its more brilliant course!"

II.—THE COMETS.

The extraordinary objects to which I shall now direct attention, received a very easy and apparently simple explanation from the Nebular Hypothesis. Confirming, by their structure, the existence of Nebulous matter, they drew the explanation of their own seemingly capricious conditions from the fact of its wide diffusion. I previously named them "Hand-specimens of the Nebulæ;" but again they are Monsters, as they were before. The Comets stand out, in regard of their motions and the shape of their orbits, in thorough contradistinction with the other bodies making up our Planetary System. They have no correspondence with these orderly spheres in regard either of the plane of their orbits, their shape, or the direction of their motion. We know nothing of the Comets now, farther than two facts, which are certainly of great importance.

1. They are subject, through all their wanderings, to the same law of Gravity which governs the planetary movements. In regard of Halley's Comet, whose remoteness, in the farther part of its orbit, from the planetary sphere, is immense, the certainty of its obedience to the law of Gravity is so well established, that it is justly considered the grandest triumph of Modern Astronomy. Its return from its last long

wandering was predicted within six days; and this, be it observed, in reference to a period of SEVENTY-FIVE YEARS. Now, whatever these six days betoken — whether error of calculation, or the action of other planets yet unknown and farther distant than Uranus, or the effect of *Ethers*—we cannot avoid acknowledging the proof it has afforded of the all-prevalence of Law. Nowhere amid the boundless expanse of the Universe, and its almost infinite variety, do facts, however minute, stand forth to puzzle us simply by their isolation: — like the comets, they show, at least in some features, their connexion with existing order. And perhaps it is in presence of the operation of laws so vast, and when the Universe speaks to us most solemnly, that we can discern its surest indications of the immortality and great destiny of Man. Participant in the Eternal Reason to which the whole Infinite is present, and to whose sleepless eye the darkest gloom is ever light, so has he, too, even beneath the clouds of earth, the privilege to unfold and the faculty to understand, how every atom accomplishes its work in the great Serene. I have heard of materialism, and of the death of that intellect, with the frame that contains it; that dust, returning to dust, is the close of its efforts and history; that man, whose thoughts, swift as fire, can pursue, both through space and time, the course of all these material energies, and bring their actings before his view, at periods separated from his own epoch by myriads of centuries;

that he, so superior in his essence, is yet fragile as the *body* for which the grave awaits. If a fancy so monstrous could be entertained, if a dream so hideous could be real, as that the material powers had all combined to evolve their grandest product,—the power of Reason, only that it might terminate for ever in a few brief years, and pass away as the limbs weaken and the eye grows dull, whilst its ruder products, even the brilliant stars, continue to live on, under the Everlasting Light,—if the fiery Car of Being, as, with GOD at its head, it rolls through space, emits all this intellect only as sparks smote from its burning wheels, to blaze and to become extinct in vacancy,—then were that whole universe a mystery most hopeless, a riddle less resolvable than Sphynx ever propounded, a bitter and agonizing mockery, that no man in a reflective mood would perpetrate on any dependent creature. No, ye gorgeous Heavens! this is not the interpretation of your wondrous hieroglyphics! Infinite though these are, they are not dense as adamant, to close in poor man as in a vault. With his foot on the sod even of the earth, he can penetrate beyond their splendours; for it is where they shine the most solemnly that the memories of the Past cease to grieve, because linked with the certainties of the Future; that the words of the loved and lost come back, as speaking still, and that their glories the most illumine even the darkness of the grave!

2. But besides being informed by them of the universality of gravity, and led into presence of some of the grandest achievements of the human intellect, we appear to be brought, by the phenomena of comets, almost into presence of other agencies, probably as extensive and far-reaching as gravity, which will immensely enlarge our views of the mechanism of the universe. The peculiar aspect of these bodies, which promises revelations so remarkable, is their *tails*. Taken in all its generality, the phenomenon amounts to this,—that the centre of figure is not the centre of the body's mass; inasmuch as when they approach the sun, the nucleus or densest part never appears in the middle point — as certainly it would do under the mere influence of gravity, or if the interior arrangements of the particles were undisturbed by any force from without: sometimes a vast mass of matter streaming from it in a direction away from the sun; and at others (as in the case of Encke's) the body taking on an oval shape with the nucleus near one edge. Now the important question is, as to the nature and seat of the disturbing force causing this singular anomaly? Little difficulty can be felt in regard of its seat; for inasmuch as the tail uniformly turns away from the sun, we are constrained to connect the energy producing it, somehow, with that luminary. Is this energy, then, a force to drive away the tail, or one to attract the nucleus? Neither supposition is suitable to phenomena; and for

a very plain reason. If the sun exerted a repelling power (*without compensation*) on any portion of the mass of a Comet, *that* would necessarily affect the general gravitating tendency of the body towards our luminary, by *diminishing it;* and, on the contrary, if he exercised any new or peculiar attractive energy on the nucleus, the general gravitating tendency of the mass would plainly be *increased.* But neither of these effects could be produced without a necessary and easily discernible influence on the Comet's *motion in its orbit;* which, in the former case, would be deprived of part of its natural velocity, and in the latter would undergo an increase. The entire absence of this effect, therefore, is conclusive of the point we have raised: but it occurred to the illustrious BESSEL, whether the difficulty might not be overcome by endowing the sun with an energy to produce both a repulsive and attractive influence over the cometic mass—*the one exactly balancing the other;* and therefore, although by their joint action deranging the comet's internal constitution, not affecting its general gravitating tendency, and the motions thence resulting. The supposition of the existence of an energy of this description, is not gratuitous, or inconsistent with the general system of nature; for a great number of forces with which we are acquainted, act solely in this way,—not producing a single effect, but two opposite and compensating ones. Of this kind, for instance, is magnetism: and if the sun placed the comet in something of the condition in which the neighbourhood of a magnet places a needle, we should have its gravity undisturbed, but its mass, in the meantime, subjected to new agitations, and endowed with POLARITY. Bessel confirmed this view in the most indisputable manner, by observations on the comet of Halley, during its recent return. As it approached the sun, and apparently came within reach of influences not developed at a great distance, very extraordinary activities appeared to affect its entire organization. At a very early period, Bessel noticed a singular outstreaming of light from the upper part of the nucleus *towards the Sun*. Now, this outstreaming mass, whose changes of shape were most strange and instructive, soon showed itself to have a movement of oscillation or vibration, exactly like that of a pendulum,—*causing it to swing from one side to the other of the line, joining the nucleus with our luminary.* But this oscillation could be produced only by an attraction exercised over it by the Sun; just as the swinging of the pendulum is referable to the gravity of the Earth. Was this influence, then, a *new power*, or merely *gravity* exerting its energy on an irregular mass? The action of the force of gravity being perfectly understood, the *time* occupied by any oscillation due to it could be calculated with sufficient precision; and this *had no relation whatsoever to the swinging of that*

Comet. To account, then, for the extraordinary agitation of this immense meteor, the Sun required to be endowed with a power over it, wholly different in intensity from gravity: but, as I stated previously, if this power was simply and solely attractive, the orbit of the body must have been deranged: so that besides this new attractive power, which manifested its presence by the remarkable oscillation, there must have been developed, *at the same moment, an opposite and precisely equal or compensating repulsive power;* — in other words, the Sun must have cast the entire mass into a *state of polarity*, resembling, in all respects, that induced on the Magnetic Needle. It is difficult to overestimate the importance of this remarkable speculation. In the first place, it has bestowed on the Sun a new character, and enlarged indefinitely the sphere of its action. We thought before, that because we understood the action of gravity we had gone to the roots of his power and catalogued his agencies; but, indeed, there should be no such idea among man's thoughts as that of dogmatism or certain completion. These mists, evanescent in substance, although enormous in dimensions, have shown not merely the possibility but the reality of far other influences perhaps as potent as gravity — streaming toward us, and, it may be, modifying terrestrial actions. Shall I hint at cosmical mysteries, by which our world is engirt, which here, in after-time, may receive aid to their true explanation?

It will be strange, indeed, if the brilliant discoveries of Faraday, which so recently unfolded a relation between the Sun's etherial beam and the Magnet, should have been forestalled in substance by tidings from masses like these! Yes! amid the close connexion of things it may even be that the little needle which, on the wide and starless ocean, enables the mariner to track his course, is only a manifestation of that power which, in the wide wastes of the spaces, penetrates and agitates these mysterious Comets! — But, apart from the novel efficiency thus bestowed on the Sun, how important and unexpected the position now occupied by these masses themselves. Hitherto we have regarded their forms as unaccountable or capricious, as the original shape of the masses, or the form in which they have been left by the ever inscrutable agencies which gave them birth and place amid the brilliant stars: but, so soon as these shapes are recognised as issues of physical relations, *at present efficient* between them and the Sun, the probability is constituted, which not the boldest would have looked for a few years ago, that we yet shall unveil much of the mystery of their constitutions. The influence of the Sun being doubtless invariable, the fact that he produces effects so different,—bestowing on one comet merely an oval or slightly elongated form, on another a tail streaming through spaces as long as the earth's orbit, or causing a third to spread itself out, fan-like, over a large space of the sky,—necessarily involves *physical peculiarities or distinctions among these masses themselves*, which closer examination of their manifest effects will certainly, in the fulness of time, enable our race to expiscate. Whether I reflect on these pregnant facts, or on the immense power of discovery which the use of modern telescopes will bring towards examination of those mists, I cannot doubt that the theory of the comets, in regard of which we have advanced already by so few, but these most splendid steps, will one day rank among the most attractive and fertile in astronomy; and that, whether we shall ever, as we recently believed, reach any satisfactory conception of the meaning and relations of their position among the stars, they will yet often require of us, in reverent gladness, to repeat the saying quoted from Seneca by Pontecoulant: "The time will come when the most profound secrets of Nature shall be unveiled, and when posterity shall be astonished that so simple explanations of grand phenomena should for so long have lain concealed."

III. THE ZODIACAL LIGHT AND STREAMS OF METEORS.

I pass now to another phenomenon, which, in so far as we are entitled to conclude, is peculiar to our planetary system; and which the dissolution of the Nebular Hypothesis has also divorced from its former harmonious place. It was explained indeed by that hypothesis, not thoroughly, but as completely as we can ever expect, in regard of objects necessarily involved in the obscurity of great remoteness. The phenomenon itself is an apparent brilliant cone of light projected from the sun after his setting, or before his rising, in the dark sky, — always visible in clear evenings and mornings in tropical climates, and seen in ours at favourable seasons. The object had, for the most part, quite the appearance that would be presented by the sun if it were a *nebulous star*,—the remaining halo being small, but still exactly of the kind of multitudes thought to have been seen by Herschel in the heavens. There was one difficulty in the way of our receiving this explanation, which, so long as many similar phenomena seemed visible in the heavens, was undoubtedly logically disposed of by Pontecoulant and others, by being referred to some part of that unknown, which, however excellent the theory might be, must, from the position of man in respect of all ultimate knowledge, ever belong to speculations regarding the structure of the universe. The difficulty was this:—knowing the velocity of the sun's rotation, a term may be found for the ultimate or highest stratum of any atmosphere that can surround him—the limit, viz. beyond which any material particle would, in virtue of what has been called the centrifugal force, fly off from him, and assume an independent existence or orbit around him. This law was employed in Laplace's theory of the origin of our system; and it received very interesting illustration, in so far as his system of experiments could go, from M. Plateau's recent curious memoir. Now, without that reason to suspect the operation of countervailing principles, which was constituted by the supposed prevalence of Nebulous Stars, we must assume this law as the foundation of any received explanation of the Zodiacal Light. I again solicit notice for what any theory on such points can alone be. It is only our *highest probability*; and, without aiming at certainty, which is unattainable, we should receive and esteem such theories, only as the best probability we can reach. Nor, in this respect, are they different from any attempted glance of man into the recesses of the Unfathomable.—On these principles, then, the Zodiacal Light must now be regarded as in all likelihood a luminous zone circulating around the Sun, but not attached to him; and the question is, whether that agrees with all its appearances, and whether we can form a conjecture regarding its composition. Now, it is not to be denied that, on the whole, the very ill-defined dimensions and direction of the Zodiacal Light, do, as far as we can rely on existing notices, favour this hypothesis. For, in the first place, the diameter of the singular Zone does not always accurately correspond with the prolongation of the Solar Equator; neither does it always cut the Ecliptic at the same place. It would seem, indeed, to be a Zone with *varying nodes* — although the variation is small — therein resembling every subsidiary body revolving around our Luminary. There is this farther: the measured dimensions of the Zone seem to vary too much to permit us to explain them by reference to error of observation or atmospherical obstructions; but they are quite explicable on the idea that this ring is, like the orbits of all the Planets, somewhat elliptical, and may therefore sometimes present a longer or shorter face to us. As to its probable composition, we must choose between the supposition of its being purely nebulous or cometic; or of its consisting of a stream of countless planetoids or meteors, too small for separate visibility, but adequate, through effect of their numbers, to constitute a general faint light. This latter hypothesis, in the mean time, must have the preference, as it strikingly connects itself with the phenomena of the periodic shooting stars. These remarkable showers of meteors, observed at different periods in August and November, seem to demonstrate the fact, that at these periods we have come in contact with two streams of such planetoids then intersecting the Earth's orbit. The cessation or intermission of the phenomena very probably is caused by a *motion of the Nodes* of these streams; so that again what has at former periods been so striking, and what was repeated in our times, will, after the requisite interval, duly return and dazzle the Earth. The speculations of Erman have added not a little to this probability; as he has shown that, at suitable periods, at opposite seasons of the year, we have experienced great deprivations alike of the Solar Light and Heat, in consequence apparently of the Streams then coming *between us and the Sun*, although, from their ellipticity, they do not touch our orbit. According to my best consideration, we have no choice at present but to class the Zodiacal Light with phenomena of this description: which thus intimate how wide we may be of truth—even as Gassendi conjectured of old—in speaking of the *vacancies* between the Stars.

IV. — THE INTERPLANETARY ETHER.

Let me recall for a moment the origin of our belief in the existence of a Nebulous Ether distinct from the Zodiacal Light, diffusing itself through all the remotenesses of our system. Suggested probably by the Zodiacal Light, and upheld by the aspects of the supposed Nebulous Stars, the theory of that Ether has yet an independent ground of its own, — which is the otherwise unexplained retardation of Encke's Comet. It is an acknowledged and generally understood fact, that if the planetary and other bodies revolved in a void around the Sun, the chief elements of their orbits would be unalterable : and that any phenomenon like a gradual drawing-in of these orbits, or a gradual approach of the bodies to the Sun, can be accounted for, in the present condition of Physical Astronomy, only by the *resistance of an Ether* pervading these supposed voids, through which, however thin it is, they have to *force* their way, like a swift rider through a calm atmosphere, which his motion converts into a *wind.* Compared, however, with the possible density of such an Ether, the planets are far too heavy and compact to show appreciable effect from its resistance. But with a Comet the case is very different. Itself a veriest feather compared with the lightest of the planets, it would be resisted by such an Ether—even as a feather when falling reluctantly through our Atmosphere ; so that the task of discerning and measuring its perturbations would be comparatively easy. Now, such a perturbation, not otherwise at present to be explained, has been distinctly manifested by Encke's Comet during all its (now numerous) returns, since first we knew, with sufficient precision, the nature and elements of its course : and we are reduced thereby to the alternative of either accepting this Nebulous Ether as a fact, or of alleging that some other cause may produce the perturbation, although it still eludes the lynx eye of Physical Astronomy. But the problem may not rest for ever in such dubiety. If other comets shall evince similar perturbations, not only will they confirm the existence of the Ether, but enable us, as they sweep through it in various directions, to ascertain its extent and shape, to tell its breadth and thickness, and also its own motions. Doubtless should these acquisitions arrive, they would bestow a new probability on the cosmogony of Laplace: for, while our System would thus stand out indubitably connected with an extensive nebulosity within itself; it could not be overlooked that this ether must exercise the most important influence on its development and fates. Encke's Comet, if it pursues its present course, must, in times yet far in the future, but certain as the prevalence of mechanical law, fall into the sun, or be dispersed by his beams. And this fate, however slowly it may overtake it, no planet can escape: so that our System, although strong and glorious, would stand out, like all other portions of finitude, subject in its mightiest arrangements to the empire of mutability —yea, ever pressing onwards from former conditions, in the manner of the more august stars, towards some term and consummation, whose character, object, or remoteness, are known only to the Infinite, whose mirror all things in their completion unquestionably are!

PART II.

THE MATERIAL UNIVERSE AS REPRESENTED IN TIME, BY THE EVOLUTION OF INDIVIDUAL GLOBES.

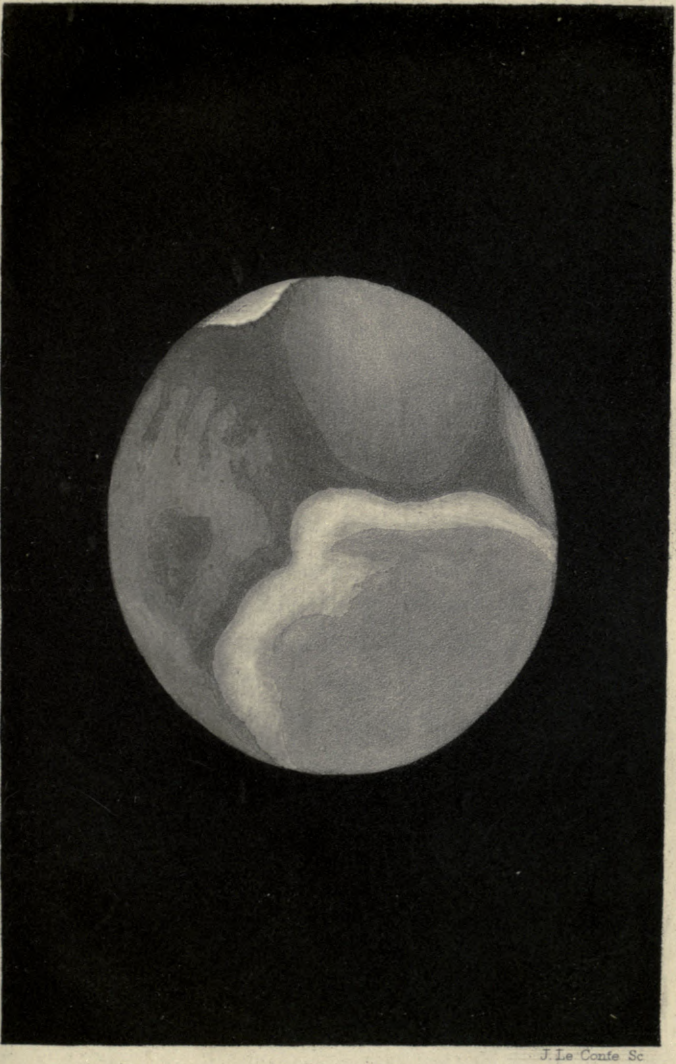
CHAPTER IV.

ANALOGY OF THE PLANETS WITH THE EARTH.—INSTABILITY OF THE EARTH.—EPOCHS OF EVOLUTION THROUGH WHICH IT HAS PASSED.

I am now to expose, in the history of our small Globe, certain similitudes of those grand processes which seem characteristic of the Material Universe, in its mightiest developments. The theatre of the events we shall contemplate, has indeed no appreciable extension in Space, compared with what is filled by the most limited group of celestial orbs; but as the Durations which have rolled over it also stretch backwards and lose themselves in the past Infinite, the neighbourhood of its phenomena, and their consequent comparative distinctness, manifestly adapt it for illustrating with an especial clearness—at least in some of its departments—how this stupendous Creation unfolds itself along one of the co-ordinates within which it is contained.

In reference, however, to the lofty task to which now I summon it, our world by no means stands unaccompanied or alone; for that remarkable feature, which, when duly analyzed, reveals its unceasing Instability, belongs also to the other spheres that, as its co-attendants, likewise roll around the Sun. Wherever the gaze of the telescope has clearly pierced, the surface of the Planets are discerned to be marked by singular inequalities of outline,—depriving them entirely, as well as the earth, of those perfectly smooth and unbroken spheroidal forms, with which, under the simple action of the power of gravity, they must all have been rigorously endowed. It were not desirable, nor is this the place, to explain under what evidence or aspects, a fact so replete with interest can, in our present knowledge, be predicated in each of these various bodies; but, for illustration's sake, I shall refer a moment to what has been learnt of two of our companions. One face or hemisphere of Mars when somewhat gibbous, is approximately represented in Plate X. Now, as the shades characterizing that picture

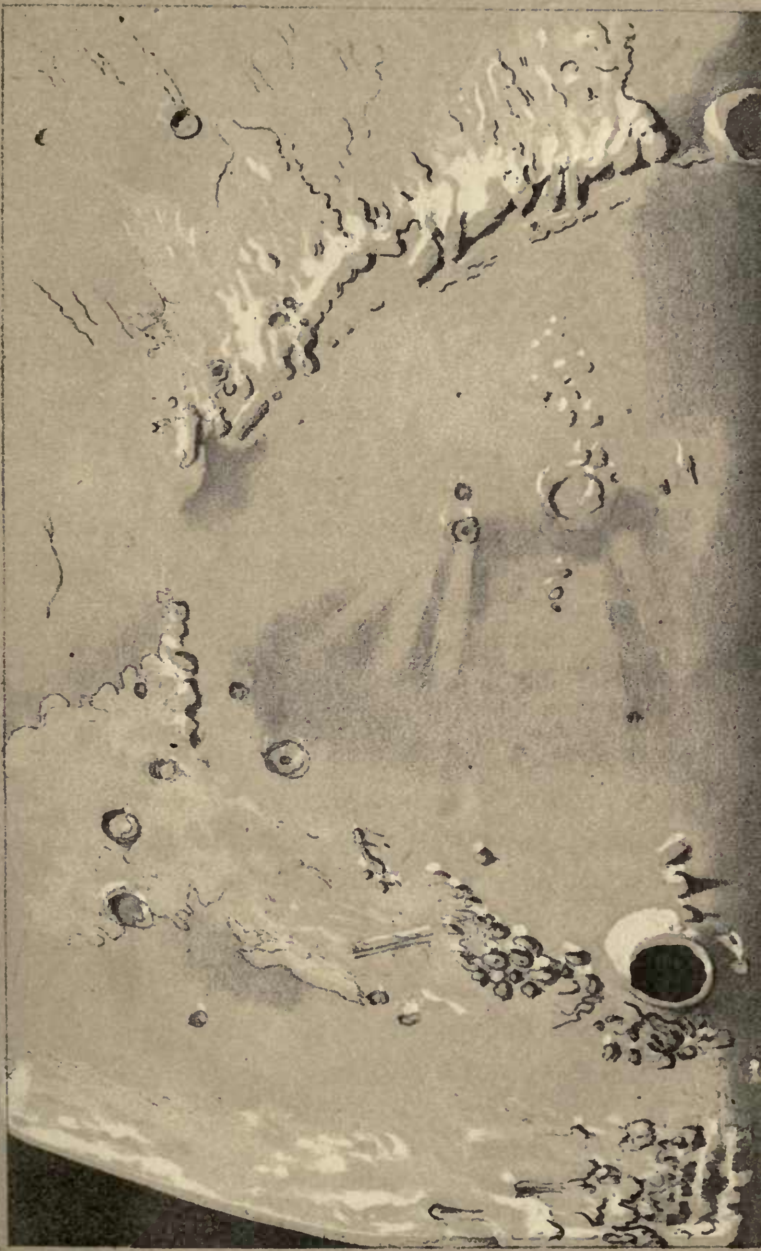
PLATE X.



J. Le Conte Sc.

THE PLANET MARS

are altogether stationary, they can have no relation to mere atmospherical phenomena, like the varying spots which often obscure the brilliancy of Venus; and, therefore, it seems conclusive that they betoken terrestrial peculiarities; or, what is the same thing, show that the body of the planet is divided between substances of very different efficiency in reflecting the incident light. But, as *water* absorbs much light, while *land*, on the contrary, reflects a large portion of all that falls on it, the distant view of our own globe would precisely resemble this aspect of Mars in its leading features: and the different reflective power of various soils would bestow on the brighter parts a mottled appearance. This analogy may seem very faint: but it is much strengthened by another singular phenomenon around the *poles* of our neighbouring planet. These are surrounded by brilliant spots, exactly resembling our polar snows; and, just as with ours, each spot contracts itself during the summer of the Hemisphere to which it belongs, gradually again enlarging with the approach and increase of winter. Appearances so nearly identical, reaching us through so vast a distance, must be received as eminently emphatic, and certainly they press towards but one conclusion, — viz., that this picture represents the *land* and *sea* of Mars; and therefore that the telescope has here unfolded, as an attribute of this orb, that uneven and broken surface—that division into high land and valley — which characterizes the vertical profile of the surface of the Earth. But if farther distinctness be still wanting, we find it most abundantly in the Moon. The disc of our Satellite, in every phase, exhibits its structure with a clearness as great as the aeronaut could desire, when looking from a considerable elevation, and through a pure atmosphere, down on our terrestrial ranges. The surface of our Luminary is visibly separated into plain and high land, — the latter portion of it actually bristling with mountains: in some places isolated peaks disturb its evenness; elsewhere, long and lofty ridges stretch onwards, encircling extensive flats; and over a large area, those remarkable craters or ring-shaped mountains are studded with extraordinary profusion. Plate XI. exhibits the appearance of a portion of the Moon, as seen through a very ordinary telescope; and it may be imagined that, were our Luminary inspected by Lord Rosse's noble mirror, how entirely the illusion of her silvery stillness would be dispelled!



EDGE OF THE MARE IMBRIUM

What, then, is indicated by phenomena so strange as these? What mighty commotion sweeping through all the spheres of our planetary scheme, or with separate roots in each orb, has torn their natural contours, and thrown them thus into most fantastic shapes? For the Ocean — image of capricious mutability — even in its wildest moods, when its billows are swelling into mountains, curling, and bursting, and resolving into foam, has a surface far more explicable and obedient to the grand Power of Gravity, than any part of these solid Lands!

It is fortunate that our earliest thoughtful review of these singular phenomena, as they are now developed on the surface of the Earth, easily conducts towards the fundamental truth of the Inquiry; nor is the light the less welcome, that it first presents itself in the form of a bold though natural surmise. When endeavouring, with the earnestness belonging to it, to render any object or phenomenon intelligible, that is, to discern the relations that fix its place and functions in the Universe, the Mind, I would emphatically repeat, is limited to two Inquiries: Has the object before it relations to other objects now around it *in*

Space, and from these is the explanation of its existence to be drawn? or must it be regarded as *one of a series of events*, deriving its significance from that which preceded it, and that whose being it will shape after itself has perished? If, on full examination, we fail to discern correlation between the fact contemplated and some other existing system; or, what is the same thing, if we cannot recognise it as an essential part of any present arrangement, we are forced, by the strength of our convictions that a place and import among Nature's harmonies must be found for it, to conclude, unhesitatingly, that its character must be determined through relations held by it, not to *Space*, but to *Time*: and its very isolation among surrounding things, or its apparent incompleteness, constrain us irresistibly to regard it as only one part or term of a Series complete in itself, but whose sum or completion must be sought in the collected contents of a vast duration, and not in the value of that single term which the progressive unfolding of the series has thrown up for the moment. Now, if we thus interrogate the existing configuration of the Earth's surface, or that distribution of massive elevations and immense valleys, which are the emphatic exponents of the action of the forces that have disturbed it, we find an irregularity so striking, and an absence so entire of connexion with any existing forms or class of stable phenomena, that if we think of that configuration only in respect of its relationships with the contents of surrounding space, we have no choice but to consider it the offspring of the wildest caprice. It is scarcely conceivable, for instance, that, if this system of heights and hollows had reached the condition of finished productions, they would exhibit no connexion with the feature of the earth, to which they are the most closely attached; and which, of all the attributes of our globe, seems to have approached most nearly to an ultimate state, viz., its *spheroidal form*; and yet there is no trace whatever of relationship. Divide the earth by the equator, and note the contrast of the hemispheres! Divide it again, from north to south, by opposite meridians, enclosing America in one hemisphere, and where is the remotest approach to uniformity? From the distribution of the land in masses, turn to the *figure* of each of its parts, and the geometrician's eye will yet discern no vestige of order or rule. Take, indeed, any portion of land and water, change and re-divide it as freely as in the old legends of Samothrace, — suppose even the largest of our continents transported, by a freak, to any new locality, or sunk wholly beneath the waves, and yet the most fastidious geographer would be offended by no breach of symmetry. In the midst of a vast plain, resting on fields of moss, and apart from rock or mountain, I have seen a huge block of granite, which no human power could have brought there; and, withal, so divorced from its kindred, and, apparently, so strange and barren of existing purpose, that what marvel if some Titan or Lapith has been fancied to have hurled it; for only a power above law could be held to have imagined a deed so unassociated with the usual order of Nature; but the incongruity which is here so visible, because all the related forms lie within the comprehension of a single glance, re-appears — only on the vastest scale, — when, rising above the systems of their special localities, we contemplate Mont Blanc, or the Himalaya, or the mighty Asia, as related in position to the whole surface of the globe. Turn, now, from the earth's *figure*, to any other fixed attribute; and if the order of these forms is sought to be explained by any relations they may bear to it, the result will be precisely the same. Nay, looking beyond earth's bounds, into the solar system, we discern the absence of all connexion between these capricious upheavals and the *magnitude* even of the orbs whose contours they form; for, notwithstanding the comparative minuteness of the Moon, its naked precipices rise to an elevation probably not surpassed in the most mountainous regions of our world. Nowhere, then, among surrounding things is the key to this mystery to be found; and once more the mind concludes—and not without deep anxiety — that the phenomena before it are part of the evolutions of Time. The isolated boulder of which I have spoken, thus interrogated, appears monstrous, or an anomaly, no longer; speaking, on the contrary, of strange revolutions of the earth, of resistless *currents* sweeping over continents and hurling it along with them; or of *icebergs* floating it from the north, and depositing it where it lies, the land now around it having then been at the bottom of the ocean; or of *glaciers*, sliding down from mountains that have disappeared, and bearing it on their surfaces, along with other spoils. Mightier far, more stupendous beyond comparison, but surely not more improbable the conception of changes which, when grouped from their beginning, shall banish caprice from the massive forms of these worlds, and reduce their confusion within order. If our measure be the life of Man, or the succeeding graves of his generations which are obliterated by only a slight turning of its soil, or Dynasties which disappear, Empires, or even the duration of Races of our kindred, we still shall speak of the everlasting hills; for the great Globe yet stands fast: but only listen more intently, and through the silence of the ages, the clangour is heard of a new and stupendous drama — a drama of which continents and oceans are the shifting scenes: — Mutability again asserts its reign over all that seems still firm and undisturbed amongst the finite shapes that surround us.

I.

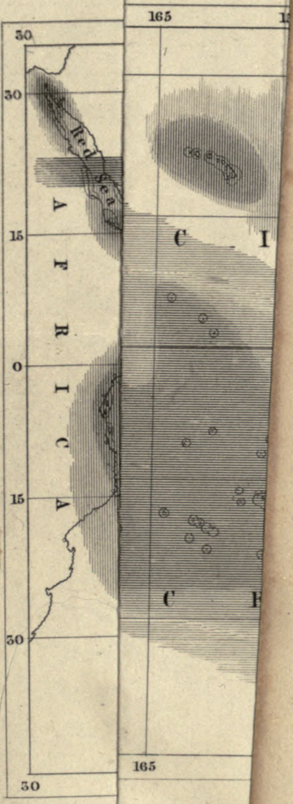
The speculation with which I have opened, evidently demands the confirmation of positive discovery; and it has amply received it, from the most solid investigations of Geology. That the loftiest masses of our globe have not only changed their elevations, but have been and probably will be subject to a continued oscillation, is indeed susceptible of a superfluity of proof; nor shall I attempt more than to adduce such facts, as may make plain the character of this grand progression of events.

1. The vast expanses of the Southern ocean are peopled near the surface by inconceivable throngs of creatures of extreme minuteness, whose continual, incessant, and inexplicable activities, are nevertheless efficient towards building up the Coral rocks. The chemistry by which the Nautilus elaborates its gorgeous shell, apprehended by the instinct of these living molecules, enables them,

as they work in myriads, now to erect a fabric solid and extensive as a bed of limestone, now regular and convolved like the human brain, and again so delicate in fibre and of whiteness so snowy that it equals some cherished plant in fragility and beauty. Now when traversing the Pacific, the Naturalist meets with a display of this architecture of most peculiar arrangement, and which by its magnitude, and immense diffusion — for its separate instances are strewn along many thousand miles — has never failed to fill him with a just astonishment. It is an island — if island it may be called—which consists simply of a circular coral reef, of the average width of a quarter of a mile, enclosing an area varying from a mile to fifty or sixty in diameter. The features even of one such object are sufficienty singular. The insects, for instance, that formed it cannot live beneath a certain depth, and the coral fabric, often arises in the midst of waters so deep, that we can nowise fancy it to have been built up from the bottom of the ocean. The difficulty was at first apparently overcome by the supposition that the creatures had reared their stupendous walls on the rim of the crater of a submarine volcano long, probably, extinct; but, overlooking the improbability of craters existing there of a size that rather likened them to the prodigious formations in the Moon than to any exemplar upon Earth, the explanation failed in regard of the two most important and characteristic facts of the case. In the first place, the existence of the coral reef has been recognised at depths quite beyond the limit at which any insect can now carry on its work: but, inasmuch as this phenomenon might be supposed only to point to a disappearance, in the course of the world's history, of *species* of creatures fitted to live at such profundities, I insist the most on another argument, which seems to admit of no reply. The proposed solution takes no account whatever of the countless number of those islands which stud the Pacific, along a line of upwards of four thousand miles. The question as to the various depths at which corals, living or extinct, could possibly have elaborated these rocks, is doubtful only in regard of a number of feet wholly insignificant in respect of any large elevation; so that the foregoing hypothesis would imply the existence over that immense extension of ranges or groups of submarine volcanoes, or other mountains *differing by no appreciable amount in altitude;* and this also without regard to the absolute depths of the ocean on whose floor they rest. It were, in fact, as if over some wide continent — irrespective of valley, low land, or table land — groups and ridges arose, across whose peaks a plane might be stretched so as nearly to touch them all; and surely nothing can be conceived more opposite to what is visible — nothing less analogous to the jagged and varying outline of the most regular of the masses of existing mountains. That these coral reefs must rest on the tops of submarine elevations, is manifest; but some new feature or element is thus clearly wanting to render the theory inclusive of all the phenomena. Now this element is supplied, if, as suggested by the sagacity of our admirable Darwin, we suppose these mountains placed on an *area of subsidence*. Picture, for instance, some island, whose coasts are now encircled by a fringe of coral, gradually sinking, first beneath the surface of the waters, and by continuation of the same mysterious workings of Nature, afterwards deeper and deeper in the sea. The process, as usual with mighty operations, being eminently slow and gradual, contains nothing to disturb the labours of the tiny architects who had, in the shape of a fringe, laid the foundation of their wall. Ever as the island sank, their edifice would rise to the surface; on the disappearance of dry land in its interior, it would first assume the aspect of a circle of coral; and this, ever added to with perseverance the most marvellous, might, through all future ages, preserve its crest on a level with the waves, although the solid land that constitutes its base had long disappeared among the profoundest depths of the ocean. But the explanation, which thus meets every difficulty in the case of a single atoll, can account for their diffusion over any extent, or in whatever numbers. Suppose, for instance, that these islands of ours had, in the course of the mutability of Nature, passed through their epoch of stability, and were now slowly subsiding. In the course of centuries — their mainland having sunk under the confluence of the Atlantic and German Oceans—there would remain, of their present greatness, only a number of islets, constituted by our mountains, around which we may fancy coral fringes to begin to grow. Now—subsidence continuing — the lowest peaks would first disappear, bequeathing only an atoll as their memorial, and although Ben Nevis might remain for centuries longer, with its crest above the waters, it, too, would be submerged, and we should have no other trace of its existence. The area of Great Britain would thus be changed into a sea of circles of coral, presenting, in miniature, what exists at present over an immense expanse of the Pacific. The conclusion, however strange, seems irresistible. Occupying that mighty area, — in length, according to Darwin, 4500 miles, and now filled only by these atolls and a few groups of islets (summits of mountains not yet wholly submerged) — a majestic continent must have existed, and taken part in the history of the Earth's evolutions, during epochs comparatively recent; and, of all the gorgeous life and lofty activities which must have thronged it, there remains but the incessant working of those infinitesimal creatures, whose structures so emphatically indicate the place of its tomb.

2. But other features of those seas are equally pregnant; and we must peruse them ere the picture can be complete. Whilst immense and uninterrupted tracts are characterized by the exclusive presence of these atolls, many in their neighbourhood exhibit a totally different character. They are occupied, also, by

islands; but, among them the coral rocks abound *in the interior*, often rising, in terraces, as we proceed inward, until we follow them almost to the tops of the highest interior elevations. Now, it cannot for a moment be doubted that these corals were formed under the only condition in which coral can be formed, viz., below the surface of the waves; and knowing of energies manifested in the volcanoes, which can rend the solid earth, and force large mountains through its crevices, the inference is easy, that these islands must have been *elevated*, and, as indicated by the *terraces*, perhaps *gradually*, from a former inferior level. But this inference is farther sustained and its significance extended by two important facts: First, as in the previous case, the symptoms of elevation *exclusively* characterize large isolated tracts, being, for the most part, unmixed except at their margin, by symptoms of depression, so that we cannot refer them to partial elevating movements, but to an action including *great areas within its range;* and this is confirmed by the circumstance, that, to these areas, our clearest evidence of the energy of a protruding or upheaving force from below, viz., the volcano, is at present confined. How extraordinary the scene we have here unfolded! Through all the wide solitude of the Pacific, from which no tidings were wont to come, except of scattered tribes of savage people, or of new and rich aromas, we are now summoned to discern the manifest progress of the most stupendous changes to which our world can be subject; mighty movements of its solid crust, here subsiding and carrying for ever from human sight the marvels of great continents, and, elsewhere, promising the birth of new ones, amidst the deepest silences of the ocean! In the accompanying chart, (Plate XII.,) which may assist the astonished imagination, the horizontal lines indicate areas of subsidence, while those of elevation, or whose continents seem rising, are marked by the vertical ones, — intermediate districts of indecision being pointed out by the crossing of the two. Most vain, then, merely on a passing glance of the configurations that now exist, to seek an explanation of the massive forms of the Earth! Forms, grand and imposing, but, withal, wholly evanescent! A time may come when they shall cease to be; and when, as perhaps before, the solid land of our world shall be found clustering around the Southern Pole.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Red Sea
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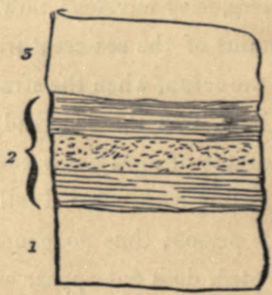
ERN OCEAN

3. Besides illustrating these grand movements in the Pacific, the chart before us manifests the efficiency of the causes alike of subsidence and elevation over large masses of the existing continents: but it was not constructed with a view to impress the fact, that there is no portion of these continents which has not been subject to such memorable revolutions. That the whole land now protruded above the waves, had long lain at the bottom of oceans, appears from the character and contents of all the sedimentary rocks; for while these demonstrate, by their structure, that they must have been deposited by the agency of superincumbent waters, they envelope, now turned into stone, the remains of the sea-creatures that lived on the floor of the ocean, when the stratum of mud, or sand, or lime, was there spread out, which through the course of ages has become hardened into a corresponding rock. To dwell on a consideration, at the present time so generally understood and accepted, does not appear needful; but a careful analysis of the rocks of these continents, has revealed another feature in the history of the changes which have affected the Earth, by far too remarkable to be passed slightly by. Not only have our existing masses of land been subjected to

a process of *emersion*, such as those tracts in the Pacific are undergoing, by whose gradual rise novel forms and combinations are visibly preparing, but it is certain that they have experienced many and signal *oscillations*, now sinking beneath the sea, now reappearing, so that those grand metamorphoses of the surface of our Planet, seem almost without limit or end. Look in illustration to the south eastern counties of England. We discern there, as characteristic of extensive localities, three singular formations of considerable thickness, lying with regard to each other as below:—



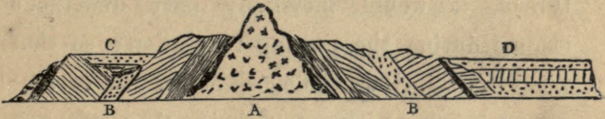
The lower and upper formations, Nos. 1 and 3, are *marine*, that is, they contain solely the relics of creatures that lived in the sea; while the middle one, No. 2, consisting of three distinct beds, is entirely, or very nearly, of *fresh-water* origin. Now observe the significance of this curious intermixture. When the stratum No. 1 was deposited, it is indubitable that the whole wide surface over which it is diffused, must have been the floor of the ocean. On the deposition of No. 2, which required the agency of a lake or river, the first bed must have arisen from its previous depths, and constituted part of the dry land. Ages then had passed,—the beds of No. 2 being meanwhile formed, in quiet and perfect order; and, at the close of this period, the land must again have sunk, and received from the ocean the superincumbent chalk of No. 3, which by one more of those stupendous revolutions has since been heaved up, so as now to constitute the bright cliffs of that portion of our island. Two grand movements of upheaval, and one at least of subsidence, are thus demanded for the explanation of this mere leaf in the annals of the Earth; and a minuter inquiry would only add to the variety, and the better impress the majesty of these changes. The intermediate fresh-water formation, for instance, (the Wealden,) was the estuary of a river, rivalling the Ganges, which there delivered its volume of water into the ocean.

Now that river must have drained some continent of magnitude corresponding,—a continent (as we learn from the scattered bones buried in the mud of its estuary) filled with life in some of its strangest and most gigantic developments; and that has wholly disappeared; carried downwards, either entirely or in parts, by the subsidence which prepared the Wealden to receive the chalk! No wonder if, in presence of mutations so extensive and incessant, the geologist should connect associations of permanence rather with the varying ocean! Yes! Change is the imperious law of Time: it is only on the great Dial of Eternity that the shadow remains motionless, thrown from the same source for ever!

II.

With such assurance, then, of the truth of our first anticipations, let us attempt, by minuter scrutiny, to ascertain the nature of these stupendous changes, and something concerning the extent of the Durations they fill. That the portion of the Past which has thus arisen from its tomb, includes immensities that are incomparable with ordinary epochs, follows necessarily from the nature of the forms with which it seems replete; for we cannot speak of the breaking down of continents, and of mighty rivers of former periods, whose existence is revealed only by their alluviums, without turning in thought to a Ganges or a Mississippi, rolling as if eternally, yet sure also to disappear,—and again discerning, not without emotion, that our grandest and most imposing stabilities are only as quiet moments in the flow of that awful Instability which evolves the destiny of Things. It is, however, most fortunate, that here our contemplations do not need to be diffused over a mere vague and unfathomable expanse; for, even as the different magnitudes of the Stars lead us gradually through Space—thereby enabling us to apprehend its vastness — there are phenomena, quite within reach, which divide this Past into subordinate and successive portions: planting, as it were, milestones along its course, and conducting us backwards, through definite and intelligible stages, until, as with our views of Space, we again reach the Infinite.

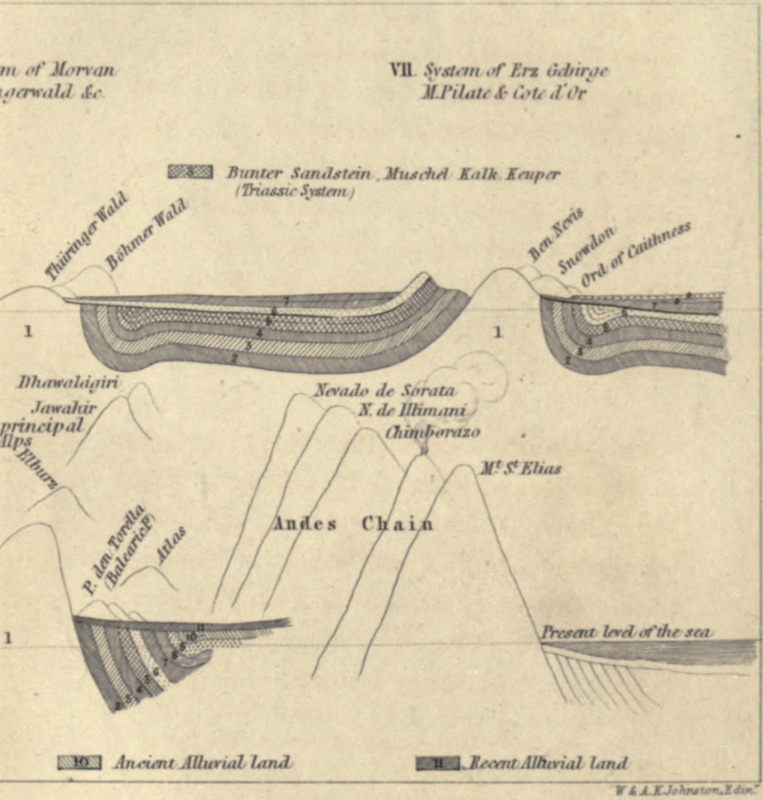
The considerations which entitle the Geologist to constitute successive epochs in the History of the Earth's mutations, are extremely simple. In the first place, it must be manifest that, inasmuch as the sedimentary rocks have been deposited by water, the natural position of these beds is a horizontal one; so that strata, with marked *inclinations*, cannot now be as they were originally laid down. But horizontality of position in the actual state of the Earth is by no means a universal or even usual characteristic of these formations, which, on the other hand, lie mostly as below, inclined towards some mountain ridge, whose protrusion had, at some period, disturbed the Earth's crust, and turned up these originally level masses.



The central mass A, in this sketch, is usually not stratified but crystalline, and by it, as the proximate instrument, the stratifications at B and B have been thrown into their present obliquity—a fact strongly confirmed by the circumstance, that the beds on the opposite flanks of it, usually recur in the same order, and seem the original continuations of one another. Now, as there can be no doubt that the protrusion of the mountain A must have occurred subsequently to the deposition of the strata it has thus disturbed, we have here one clear datum regarding the age of that movement of elevation, viz.: it must have taken place *after the epoch of the formation of the newest stratum it has upturned.* But, in connexion and contact with the upheaved rocks, others are generally found lying on their edges as at C, or flanking them as at D, which still preserve their original horizontality; and it is quite as clear that the revolution in question must have occured *prior to the deposition of these.* Had any such bed existed when the class B, B, was disturbed, it would inevitably have undergone change during the passing revolution; so that we can now include the epoch of the rise of that mountain mass within two limits, the nearer one being the age of the oldest sedimentary rock in its neighbourhood that is not disturbed, and the remoter, the age of the youngest stratum whose position is inclined. The limits, indeed, may be widely apart, and contain durations that would seem immense if computed by revolutions of our Globe around the Sun; but withal they are usually sufficiently definite, and enclose an interval as small as we can deal with, or even recognise in Geology. The point now established is of high importance, but it is evidently quite limited — only enabling us to establish a chronological relation between *each individual mountain*, or mountain chain, *and the sedimentary rocks around it.* Can we, however, by any farther generalization, connect remote and diverse mountains,—can we, for instance, shape our principle, so that it will enable us to ascertain the relative ages of the Scandinavian Alps and the Pyrenees?

But since we have obtained the means of referring these Norwegian and Spanish chains, each to its own neighbouring sedimentary rocks, the question I have started is manifestly equivalent to another — *are distant sedimentary formations related?* Now, as many of the rocks of deposition can be traced continuously over very large tracts of country, it is plain that where these occur, we are certain that we are dealing with the same monument of the same epoch in the World's History: but even when a formation is confined to a comparatively small basin, the research and sagacity of observers have enabled them to detect in other regions, sometimes by similarity of position, at others by lithological character, or the nature of its fossils, the exact analogon or chronological *equivalent* of that special bed. The attainment of a power so remarkable, is one of those signal achievements which amply vindicate for the Geology of modern times, a position among the fixed and solid sciences; and surely the distinction were very hardly to be gained, could we justifiably withhold it from knowledge so laboriously collected, and admirably systematized, that it can guide its earnest follower by means of patches of alluvium sparsely scattered over the Earth — now appearing in England as the Wealden, again in France, then in a remote district of Scotland, and probably in distant India — to the idea of contemporaneous rivers draining ancient systems of continents whose memory, as well as their existence, might have been lost for ever, and depositing, like our largest streams, the debris of the countries by whose waters they were fed, in immense deltas at their mouths ! Regarding the mutual relations of the sedimentary strata in reference to time, no important difficulty, indeed, any where remains; so that the determination of the *absolute* age of a chain of mountains, with regard to its neighbouring rocks, carries distinctly along with it the determination of its *relative* age, and entitles us to fix the epoch of its appearance in the series of our World's grander revolutions. The truth on which I am touching appears to have been discerned with various distinctness by several contemporaneous inquirers; but the perception, full and complete, of its extraordinary import, as well as the first systematic development of all its relations, Science unquestionably owes to the Frenchman DE BEAUMONT. In the hands of this illustrious Geologist, the few and simple conside-

PLATE XIII


m of Morvan
gerwald &c.
VII. System of Erz Gebirge
M. Pilate & Cote d'Or
8 Bunter Sandstein, Muschel Kalk, Keuper (Triassic System)
Thüringer Wald
Böhmer Wald
Ben Nevis
Snowdon
Ord of Caithness
1
2
3
4
5
6
7
8
1
Dhawalagiri
Jawahir
principal
Alps
Elburz
Nevado de Sorata
N. de Illimani
Chimborazo
Mt. St. Elias
Andes Chain
P. den Torella (Balearic P.)
Atlas
1
Present level of the sea
10 Ancient Alluvial land
11 Recent Alluvial land

W. & A. K. Johnston, Edinr.

rations above unfolded, constituted by their combination an era in our mode of contemplating the History of the Globe. Conjoining the fact that *parallel* chains, although widely separate, are mostly contemporaneous, those massive elevations, once suggestive only of confusion, now stand forth arranged in mighty groups — each being a special landmark amid the drear solitudes of the Past—bringing to the Reason which has dared to adventure so far, something of the same welcome assurance with which the sight of a marked stone gladdens the traveller through a trackless moor.

De Beaumont's chart, (Plate XIII.) appended to his celebrated letter to Humboldt, emphatically illustrates this great subject; — the visible progressive deposition and successive upturning of the sedimentary strata being there represented and impressed with a distinctness much surpassing aught attainable by elaborate descriptions.*

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* The significance of the map appears on the face of it. Notice, for instance, Systems XI. and XII. By System XI., No. 9 of the sedimentary rocks is upheaved, while No. 10 is horizontal,—whereas in System XII., No. 10, is also upheaved, — thus marking two successive epochs. The other Systems exhibit similar phenomena.

Standing on the peaks of the Andes, whose origin belongs to the modern or existing epoch, how extraordinary and imposing the perspective which greets the view! Nearest in point of time, but scattered over the world's surface, like stars of the first magnitude through the heavens, we discern, (System XII.,) the mighty Himalaya, the peaks of Caucasus, the leading Alpine chain, Atlas, and other cognates. Lying behind these —equally dispersed, but with their distinctness diminished by distance, Mont Blanc rears its pinnacles, the Cordilleras of Brazil, the Scandinavian Alps, and many minor parallel chains that burst from the interior during the same epoch of commotion. Farther among the recesses of the Past, Lebanon arose, and the Ural, and Corsica and Sardinia; beyond which, separated by an interval like that which divides the orders of fixed stars, we recognise the Pyrenees, Apennines, and Alleghanies. Across these latter peaks Ben Nevis and Snowdon are descried, venerable with age; and, finally, the eye, wearied with the immensity of its range, loses itself, not unwillingly, amid the mists that overhang the origin of the transition rocks. Stupendous elaboration of Nature! as a whole indeed, inconceivable: —let us reflect, therefore, for a moment on some of its minor stages. On examining System II. on the chart, it seems clear that, when those commotions shook our planet which, by twisting and upheaving the transition rocks, produced the hills of the Bocage, not a trace of the great coal formation (3) could have been in being; for, as exhibited there, it is lying evenly on the upturned edges of the other. But its dislocation and upheaval by the next system proves that, before the earth was again disturbed, that profusion of vegetable life, of which it is the significant remains, had obtained its full development ; or that this solitary period of terrestrial history included the apparition and prolonged existence dispersed widely over the earth's surface of continents or mighty islands, teeming with a gorgeous vegetation, the accumulation of whose leaves and stems through ages that are surely countless, produced the substance of that consolidated rock on which, during subsequent revolutions, so many other depositions have since been laid down by the sea. Now, the history of this single era, necessarily including vast and multiplied, though orderly changes, — for it contains the development of vegetable life until it reached an extreme exuberance, — might well be estimated, according to our usual modes of thought, as an adequate history even for a world; but, on the map, it occupies the shortest span! Turn now to Systems VII. and VIII. The disturbance indicated by VII., amid which Snowdon and Ben Nevis arose, first upheaved that Jura limestone, a part of the Oolitic series. Now it is on the Oolite as their floor that these extraordinary formations, of which I have already spoken, viz., the remains of the Deltas of ancient rivers, uniformly rest; so that it may have been in connexion with this very convulsion that the great continents, drained by them, were upheaved. But, previous to the next revolution, which cast up the Pyrenees, Alleghanies, &c. the chalk formation must have been deposited, as we find it highly inclined on the flanks of the Spanish mountains; and, therefore, in one grand throng within this mere stage of the earth's evolution, we discern the entire series of these astonishing changes I have described, viz., the apparition of continents, the life and death of peculiar species, subsequent submergence, the development of the mysterious agencies that produced the chalk; and, finally, the upheaval of that rock and its equivalents, during the rising of the Pyrennean chain!

Are the periods of operations like these to be measured by our ordinary years? Look once more at the Pacific, and at the revolutions preparing within its peaceful bosom! In what year of man's annals did these begin, and in which of his centuries will he record the date of their completion? Say, rather, whether he and most of his cognate races shall not have done their work and disappeared ere one of these emerging masses of land shall have permanently overpassed the surface of the waters, and mingled, as a continent, among the destinies of the Earth!

It is possible, however, to subdivide even these secondary epochs; and, that our ideas may become still more definite regarding the nature of this important subject, I request attention to a single incident in the course of the most recent. The geology of Sicily places it beyond a doubt that the rise of Etna belongs to the newest epoch in the history of our planet;—it began to pour out its fires not very early in the morning of the existing day. An inspection of the accompanying map, Plate XIV. will make this quite apparent. Resting on an extensive secondary formation, contemporaneous with our chalk, are extensive beds named the Newer Pliocene. That these were formed under the sea is indubitable, because they are full of marine shells : and the recentness of their origin, geologically speaking, is equally apparent, inasmuch as with very slight exceptions the shells they contain are precisely those at present abounding in the Mediterranean. Now while the Pliocene beds were being deposited, a neighbouring submarine volcano — the earliest apparition of the gigantic Etna, burst out like Graham's Island, and mingled with them its tuff and ashes. The date of this phenomenon is manifestly the earliest occurrence of these ashes ; and this is recognised among the beds (now upheaved) suitably distinguished in the map on the south of the plain of Catania. So modern, then, being the origin of Etna, can we approximate to its positive duration? In the history of this great mountain there are also visible epochs. By the recent researches of Waltershausen,* a succession of grand craters have been revealed in its structure, — the earliest probably being situated in the

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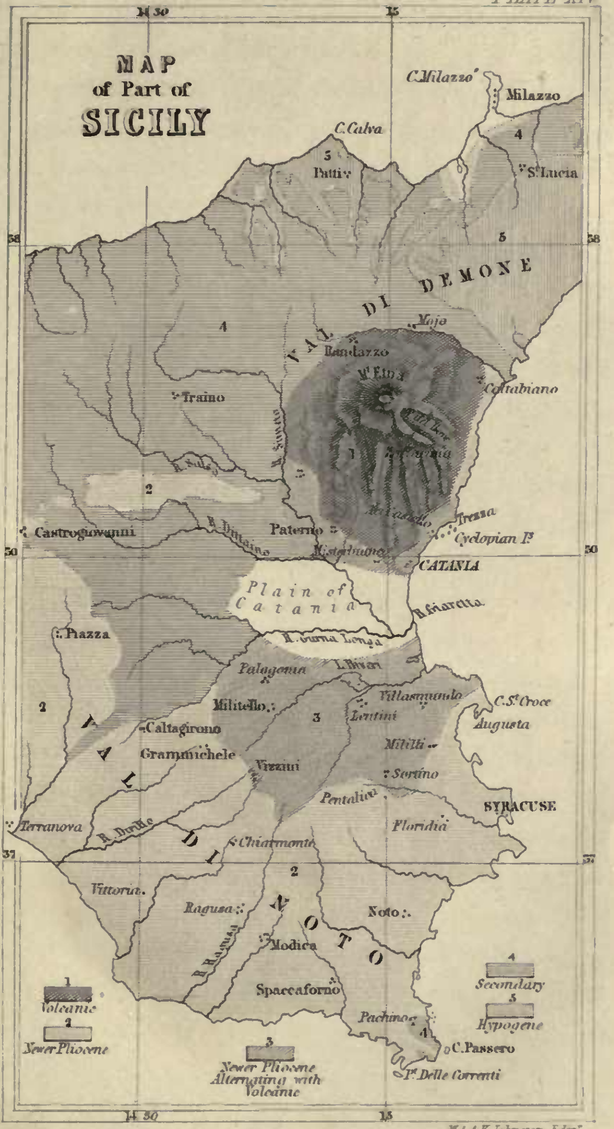
* I would beg especially here to refer to the splendid Atlas, now publishing by Baron Waltershausen. It is the result of eight years' patient study of Etna, and unquestionably the most perfect monograph in existence. The Baron has just undertaken the study of Hecla.

PLATE XIV


MAP
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C. Milazzo
Milazzo
C. Calva
5
Patti
4
S. Lucia
5
VAL DI DEMONE
Mojo
Randazzo
M. Etna
Traino
Cattabiano
R. Simeto
1
Catania
R. Salso
2
Nicolosi
Trezza
Cyclopian Is.
Castrogiovanni
R. Dittaino
Paterno
Misterbianco
CATANIA
Plain of Catania
R. Giarretta
Piazza
R. Gurna Longa
Palagonia
L. Biviere
Militello
Villasmundo
C. S. Croce
2
3
Lentini
Augusta
Caltagirone
Grammichele
Melilli
Vizzini
Sortino
Pentalica
SYRACUSE
VAL DI NOTO
Terranova
R. Drillo
Floridia
Chiaramonte
2
Vittoria
Ragusa
Noto
Modica
R. Ragusa
Spaccaforno
Pachino
4
C. Passero
Is. Delle Correnti
14 30
15
1
Volcanic
2
Newer Pliocene
3
Newer Pliocene Alternating with Volcanic
4
Secondary
5
Hypogene

W. & A.K. Johnston, Edin.

heart of the Val de Bove. Now each of these immense vents, doubtless had a history of its own, not inferior in extent or importance to that of the existing one, to which the present contour of the mountain belongs. Besides the existing principal crater, the surface of Etna is studded with minor cones, the mouths of lateral eruptions, all the produce of its modern epoch. But it has been computed by Mr. Lyell, who has certainly yielded to no spirit of exaggeration, that these eighty minor cones could not have appeared in less than twelve thousand years; and yet, if we strip these from the mountain, we should simply fall back on the next great crater in the series of Waltershausen, and Etna would remain as now, the giant and the marvel of those Sicilian regions! If this, then, or something like it, is the significance of only one movement of the second's hand of the clock, by whose course the earth's annals are divided, how immeasurable the duration and majestic the fates even of our evanescent globe! Rising from this incident of Etna, and passing through the stupendous secondary epochs, which are bounded by the successive apparition of mountain chains, until, though only as with the faintness of a dream, we think we have a glimpse of all its history, the periods

I formerly spoke of as occupied by the evolutions of the stars, startle and astonish us no more. Though the Sun, in his march through space, had penetrated to depths which contain the Nebula of Orion, our little Globe, firm and organized, may have endured through that mighty course: and if, as it rolled, I had stood on the top of the hoary Ben Nevis, and beheld the Earth, ever and anon changing beneath my feet—rising from age into youth and newness, and diversifying eternities by its phases; can it be conceived that these firmaments of stars would have rested without modification, fixed and frigid, unable to elaborate fresh developments of variety and beauty? Nearer by far to the marvels that, in this course through depths so vast, must have passed before my vision, is the thought which dawned on the illustrious Herschel—that the fantastic groups of our Milky Way will one day separate, and the zone be dissolved, even as, at some period of the fathomless Past, that throng of systems near Virgo may have belonged to our cluster, and only been reft away, as the unresting Universe proceeded with the unfolding of its infinite capacities — entering then probably only on a minute and comparatively transient phase!

III.

It must not be supposed, however, that even could we fully apprehend the course of our globe through the enormous periods whose reality is indicated by its structure, we would have reached the limits of its existence. The conception has undoubtedly prevailed, that the epochs of De Beaumont approach almost the commencements of the earth's organization, and that the lowest stratified formation now visible, is divided only by a thin layer of primary or crystalline rock, from an interior molten and amorphous mass which still constitutes the principal substance of our planet. But this notion of the thinness of the earth's solid crust, — although the problem, from its nature, is incapable of an absolutely rigorous solution,—is discredited by the best lights we can obtain in regard to it. It may seem strange that, on a subject so purely terrestrial, information should reach us in the shape of an inference from the great and universal laws of physical

Astronomy: but when the boatman desires to release his wherry, does he not wait with entirest confidence on a time computed according to the motions and influences of the distant Moon? And surely it is not more strange, that through the close relationship of things, even that same orb should communicate somewhat concerning the internal constitution of our globe. Now, a special and very appreciable motion of that globe, is caused by the action of foreign bodies on its internal constitution. The Earth, considering it merely as a planet, has three distinct motions in space, illustrated with singular felicity by the motions of the child's spinning top. *First*, it runs through an orbit; *secondly*, it turns swiftly on an axis; and, *thirdly*, its axis of motion is not steadfast, neither retaining an upright nor a fixed inclined position, but turning constantly, so that when it moves swiftly, there seems a hollow within it like the dimple of a whirlpool, or an inverted cone. A mere glance at the toy when in action, will make the nature of this motion of the axis quite palpable; and it is caused by an influence of the moon chiefly, on the earth's peculiar constitution. The mode by which the very delicate questions connected with the subject are dealt with in Astronomy, is as follows:—If our planet were a perfect sphere, it would not be subject to any such influence, or partake of such a motion; and in order to fix our ideas, and simplify calculation, we suppose it to be a perfect sphere, surrounded by a detached girdle or ring, representing the actual equatorial protuberance. The ring may thus be regarded in the first place *separately;* and we discern without difficulty, that while it must circulate with the earth in the time of its diurnal revolution, it will also, because of the action of the moon, have a progressive motion in its own plane, which is perfectly represented (let my reader here try the easy experiment,) by the movements of the rim of a half-crown that has been made to spin on that rim, immediately before the motion becomes extinct, and it falls down on the table. But as this equatorial protuberance is not a separate ring, it must plainly expend part of its force, in so far as this irregularity is concerned, in communicating its disturbed motion to the spherical part of the globe,—thereby forcing its axis of revolution to oscillate as above described: and as, in so far as it appears, the force thus expended must vary with the degree of the globe's solidity—being comparatively slight, if our planet is merely a slim shell floating over an extended fluid mass—it is clear that a definite ground is constituted, wherefrom, with all the certainty attached to the deductions of physical Astronomy, we may reach something of a distinct conclusion, on a subject even so remote.* It is not necessary to enter here on minute details; this general inference being sufficient, that to satisfy apparent requirements, the crust of our globe must approximate to *one thousand miles in thickness;* so that we are not on the surface of a planet whose encrusting has only begun; but rather modern geology, with all its enormous epochs, is itself but as a scratch, ploughing to no appreciable depth among the world's prior destinies. Not a slim shell to whose beginnings I have penetrated, but the largest part of the entire mass of our planet now rises before me organized like the film I have examined, and of whose changes, lost for ever to the eye, even the grass I tread on is doubtless a related descendant. Fathomless, indeed, the Universe! Yet nowhere, amid its awful recesses, or at any moment of its infinite course, has the petal of a lily drooped unseen, or a sparrow fallen unheeded to the ground!

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* See, for farther elucidation, the Appendix to this Chapter.

But in contravention of the idea, which would thus extend our world's history indefinitely beyond the epochs of all the organization that is visible, it may be asked, whether a barrier is not placed by the first appearance of the stratified rocks, which pass no farther than the earliest periods of De Beaumont? Now, I would state emphatically, that these are only the *earliest existing or legible* monuments of the phenomenon of stratification. It has long been understood with the better class of geologists, that the more ancient formations of this description are not now in their original condition. The contorted and crisped states in the neighbourhood of our primitive regions, have been conceived as turned from their first form of regular sediments, by the neighbourhood of that heat, which, acting from the interior, threw off the granitic masses next to them, originally molten: nay, it has been imagined by one or two of our best historians, that what we see of the granitic formations may, indeed, be only the fused former floor of the world. This supposition, even in its mildest form, evidently goes to the entire destruction of all early records: but there is no longer need of the idea of fusion, or the proximity of fusion, to enable one to recognise the reality of the changing of forms lost now for ever; but which may have filled up innumerable ages. It is, perhaps, the most striking result of modern observation, that alterations, for which the subtlest chemistry cannot yet account, occur through time, in the structure of solid unorganized masses. Even metallic alloys, which have been constructed within a definite period, exhibit the efficacy of this mysterious action, by the growing separation of their parts—presenting, in the coins of human empires, an assimilation to that metamorphosis in the coinage of the world, which, in the earlier rocks, has separated and arranged the Quartz in cakes, in beds of aluminous and micaceous slate. The illustrious VON BUCH approached this subject in his theory of *dolomization;* and prepared the way for the grander generalization of KIELHAU. Residing amid the Scandinavian Alps, this latter geologist has seen the granitic rocks shading gradually into stratified forms; or, rather, the upward progress of these latter, in every step of their course towards the compact and more perfect structure.* Hidden agencies, yet inscrutable, seem to bestow on the earth a gigantic faculty to redintegrate itself, and to assume, after the lapse of ages, that which first was taken from it as detritus, back among its crystalline forms. The grandest telescope soon loses itself in space, or ends by knowing that it has reached the frontier of regions within which man shall never penetrate: thus, too, on remounting the stream of time, our vision terminates among those mists of Mirza overhanging all beginnings, through which it is given to no mortal eye to pierce.

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* See Appendix.

Apart from the illustration yielded by the views I have unfolded regarding the history of the earth, in regard of the general economy of the universe, they have a relation to its own interior fates too momentous to be passed without notice. Confined to a definite portion of space, which might be supposed inaccessible to change, the world had grown up into what it is, chiefly through its proper vitality; but knowing, that during its existence, it must have traversed many unknown spaces, passed from star to star, and through the midst of the remotest constellations, the suspicion is unavoidable, that it may have been subjected to very varying external influences. What these influences are, how diverse, how they may affect, say our internal magnetic conditions, — this is yet wholly unknown; but there is one condition of highest importance, viz., the temperature of these globes, which, as the illustrious FOURIER first rendered demonstrative, depends in no slight degree on the character of the spaces in which, meanwhile, our habitations are. Now, whether this temperature of space is owing to the radiation of heat from all the stars around us, varying, therefore, as we go through thickly or thinly studded regions of our galaxy — or whether it is modified by our passing through *ethers* having specific temperatures, it is clear that the change thence arising has a reality, however indiscernible may be its laws, and also that its efficacy over the entire evolutions of our Globe may have been potent. We seem, indeed, already forced into the presence of that efficacy, by the complexities of a problem not apparently resolvable by any inferior laws — I mean the increasing temperature of the beds of the Earth as we descend.* If, as formerly supposed, this increasing heat betokened an approach to the central incandescent mass, it may be inferred, from the rate of its increase, that one hundred miles below the Earth's surface its entire materials must be molten; but since, as I have stated, the highest probability yet attained regarding a point so remote from the sphere of observation, has induced us to endow our Globe with a solid crust of ten times that thickness, we must search elsewhere for the solution of the phenomenon. Suppose that our system has come from spaces far warmer than our present abodes — suppose that for a time our Globe had been as if plunged into a fluid of high temperature — then it would now be giving off its heat, and Poisson's* conception of the cause of present phenomena would be realized. But this is only one instance of a probable alteration—one guess as to the result of our association with the entire Universe. It reveals, however, in its august reality, the mighty and pregnant truth, that even our World, infinitesimal though it be, holds no independent existence, or performs its course apart; since over its whole career exterior laws prevail, that widen immeasurably the sphere within which its order is contained, destroying the isolation of its events, and showing it comprehensible, even in its minutiæ, only when regarded as part of the unfathomable All! Far indeed are changes so mysterious, and passing through countless ages, from the present apprehension of our Race; but, even as I dare not say where the Almighty began his work, neither can I tell, in presence of what now is known, where his revelations to Man are to stop, or whether there is a barrier line beyond which the created reason shall never pierce. Yes! a time may come when the circle of darkness that now hems us in shall be driven yet farther back, and the twilight land, now peopled with gigantic shadows, be filled with sunshine! So, at least may we hope: not, indeed, in the pride of Intellect, or with that idle vaunt coeval with the primal curse, that the Finite mind can be as a God, but rather with the gratitude of the nestling child— WHAT IS MAN THAT THOU ART MINDFUL OF HIM, OR THE SON OF MAN THAT THOU HAST DEIGNED TO VISIT HIM!

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* It is known, from deep pits and springs coming from great profundities, that this interior temperature regularly increases, in so far as we have yet penetrated. See Note at close of the chapter.

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* See Note.

APPENDIX TO CHAPTER IV.

VIEWS CONCERNING ULTIMATE PROBLEMS IN GEOLOGY.

The important doctrines laid down in the latter part of this chapter, have not yet been made generally known in this country; and as I have no doubt that many of my readers will desire farther elucidation of them than I could consistently give in the text, I feel it right to insert that here.

I. DEDUCTION BY MR. HOPKINS OF THE PROBABLE THICKNESS OF THE EARTH'S CRUST FROM CERTAIN ASTRONOMICAL PHENOMENA.

This very striking series of deductions appeared in the Transactions of the Royal Society of London and of the Cambridge Philosophical Society. Profoundly mathematical, they cannot be very extensively appreciated; and I am therefore certain that I do good service in reprinting, with Mr. Maclaren's permission, a popular account he recently gave of them in Jameson's Philosophical Journal. The paper is not printed entire, as some parts of it do not stand in relation with the speculations in the text.

"Modern science is rich in wonders. Who would think that the sun and the moon, bodies so distant, and of which in most respects we know so little, could be interrogated respecting the structure of our globe in those deep recesses to which we, who live on its surface, cannot find access—ay, and should be able to return us distinct and instructive responses? Such is the case, as Mr. Hopkins has shown in these very learned papers.

"Mr. Hopkins's conclusions rest entirely on the effects of the sun and the moon's attraction, as indicated by the phenomena of Precession and Nutation.

"It is known that the sun itself, and all the planets and secondaries of the solar system, attract each other with forces directly proportioned to their masses (that is, their weights), and inversely proportioned to the squares of their relative distances. It is known also that the earth is not a perfect sphere, but an oblate or flattened spheroid, the equatorial diameter of which exceeds the polar by one 300th part. To express it in another form, the equatorial parts are thirteen miles farther from the centre than the polar.

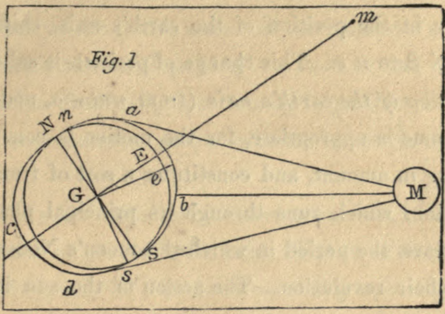

Fig. 1

"In the above diagram, the round figure G represents a section of the globe through its axis, N the north and S the south pole; *a b* the equatorial protuberance on one side of the globe, *c d* that on the other. If the earth were a perfect sphere, the moon's attraction would have no disturbing effect upon it. And though it is an oblate spheroid, the result would be the same if the moon's orbit were in the plane of the equator, that is, in the position G *m*, as in this case the force of attraction on the one side of the earth would exactly balance that on the other. But the plane of the moon's orbit is oblique to that of the equator, or in the line *b* M; and as the distance between the satellite and the earth is only 30 diameters of the latter, the action of the moon M is a little greater on *a b*, the part of the protuberance next to it, than on the part opposite, *c d*. The effect of this disturbing action is to draw down the plane of the equator from the direction G E to the direction G *e*, and to produce a corresponding angular change in the position of the earth's axis, shifting it from N S to *n s*. This change of position is called the *Nutation of the earth's axis* (from *nutatio*, nodding.) The name is appropriate, for the motion is constantly varying in amount, and constitutes a sort of tremor or vibration, which runs through its principal phases in 18½ years, the period in which the moon's Nodes complete their revolution. The action of the sun is conjoined with that of the moon, but is comparatively feeble. The secondary effect of this Nutation is the *precession of the equinoxes*, or the shifting of the equinoctial points 50 seconds westward annually, which makes the pole of the earth describe a circle of 47 degrees in diameter round the pole of the ecliptic in 25,800 years.

" The thickness of the equatorial protuberance *a b c d*, and the magnitude of the angular change in the earth's axis N *n*, must not be judged of from the figure, in which they are necessarily exaggerated. The equatorial protuberance amounting only to 13 miles upon a semi-diameter of 4000, may be compared to a band of writing-paper wrapped round the middle of an orange. The nutation makes the pole N describe a very small circle round its mean place, namely, of about 900 feet radius. To give an idea of the extreme minuteness of the change, let us suppose an iron rod 100 feet long, fixed at one end and moveable at the other, to represent one-half of the earth's axis. If the moveable end were pulled *the twentieth part of an inch* to one side, the deviation would be proportionally as great as that which the *lunar* nutation produces in the terrestrial axis.

"The earth's equatorial diameter exceeds, I have said, the polar only by a 300th part. The moon's attraction, therefore, may be considered as acting upon the part *a* with the aid of a lever a fraction longer than if the earth had been a perfect sphere. The difference is very small; but when we also recollect that the moon's attraction at *d* counteracts her attraction at *a*, and that it is only the difference between the one attraction and the other depending on the inequality of the distance, which disturbs the earth's position — and further, that the mass or weight of the disturbing agent, the moon (which is the measure of her power), is only the 68th part of that of the earth — when all these circumstances are considered, it might be inferred that the effect of causes so very minute would be inappreciable. Such an inference, however, would be erroneous. In truth, the *effect* was discovered first, and led to the knowledge of the *cause*. Dr. Bradley detected a change in the latitude of the stars, which, after increasing for nine years, diminished for the next nine, and amounted in all to 18 seconds. He observed that its period coincided exactly with that of the revolution of the moon's nodes, and was thus led to the discovery of the cause.

"Cavendish's celebrated experiments with lead balls have been lately repeated at the expense of Government; and the conclusion drawn from them is, that the mean density or weight of the earth is rather more than 5½ times the weight of an equal bulk of water. Now, the rocks at the surface are only about 2½ times the weight of water, and to make up the mean density or weight of the whole to 5½, it follows that the interior must be as much above that as the surface is below it. We thus arrive at the conclusion, that the density increases with the depth beneath the surface.

"Astronomers simplify the problem by considering the protuberance, *a b c d*, as a ring detached from the spherical mass. The action of the moon in shifting the axis of such a ring, revolving in free space, would be very great; but it is reduced to the very minute quantity I have mentioned, because the sphere, to which the ring is attached, has no tendency to change its position, and resists the change in the ring by its *inertia*. The ring, in short, has an incomparably larger mass to drag after it, and hence undergoes but a very slight change of position.

"The magnitude and density of the globe being known approximately, and also the magnitude and density of the ring *a b c d*, the action of a body like the moon, whose mass and distance are known, can be subjected to mathematical calculation.

"Mr. Hopkins first investigates the phenomena of precession and nutation on the hypothesis that the earth is of uniform density throughout, and in this case the conditions of solidity and fluidity are considered. His chief object here seems to have been to test the accuracy of his process, and we need not therefore stop to notice the results. He then passes to the case in which the earth is assumed to be, what it really is, a body whose density is variable, increasing with the depth, and is modified by the conditions of internal fluidity and solidity.

"The mean density of the globe is about the same with that of the heaviest iron ore, or 5½. Keeping in mind that the force of attraction is in proportion to the quantity of matter, let us assume the ring, *a b c d*, to be of the same density with the sphere G, or 5½ times the weight of water. In this case its effect, under the moon's attraction, in disturbing the position of the earth's axis, would be in proportion to its relative mass, and its distance from the earth's centre. But if the density of the ring were only that of brick, or 2 times the weight of water, its disturbing effect upon a sphere of the superior density of iron ore would be comparatively trifling. If, again, the ring had merely the density of pine wood, which is but the 8th part of that of iron ore, its disturbing effect would scarcely be appreciable by the nicest observation.

"But the density of the ring, and the average density of the globe, are not the only elements involved in the problem. We have further to inquire into the constitution and distribution of the matter in the interior of the globe. We know that it is solid at the surface. Is it solid to the centre—that is to say, is it composed of parts immovable *inter se*? We know also from volcanoes, that there is fluid matter within it, that is, matter whose parts are movable, and obedient *inter se* to the laws of gravitation, external attraction, and centrifugal force. Does this fluid matter compose a large or a small part of the entire mass? Is it situated near the surface, or at a vast depth? The disturbing action of the moon will not be the same upon a globe all solid and upon one nearly all fluid. It will not be the same upon a globe in which the solid shell forms one-half of the mass, and another in which it forms only one-tenth.

"These statements will convey a general idea of the conditions of the problem which Mr. Hopkins had to solve; and he seems to have been careful to examine it under all its various forms.

"The conclusion to which his researches have conducted him is thus announced:—"*Upon the whole, then, we may venture to assert, that the minimum thickness of the crust of the globe, which can be deemed* *consistent with the observed amount of precession, cannot be less than one-fourth or one-fifth of the earth's radius.*" That is, from eight hundred to a thousand miles.

"Let it be observed, that this is the *minimum* thickness consistent with the known precession. The actual thickness may be much greater. The globe may even be solid to the centre, and this, too, without very materially altering the conditions of the problem; for if the shell is a thousand miles thick, it constitutes *four-sevenths* of the bulk of the globe; and though the remaining *three-sevenths* may have a higher density, the action of disturbing forces upon them from without is greatly lessened by their central position.

"Mr. Hopkins's conclusion, no doubt, rests on a narrow enough basis. It is something like an estimate of the distance of the stars, deduced from a difference of one or two seconds in their apparent position — a difference scarcely distinguishable from errors of observation—but in the absence of more direct and positive evidence, we are thankful to obtain it. We believe it to be correct in principle, and that its errors, if any, are errors of degree; and the views respecting the structure of the globe, to which it conducts us, are in harmony with facts derived from other sources.

"'The results arrived at,' says Mr. Hopkins, 'have an important bearing on our physical theories of volcanic forces, and the mode in which they act. Many speculations respecting actual volcanoes have rested on the hypothesis of a direct communication by means of the volcanic vent between the surface and the fluid nucleus beneath, assuming the fluidity to commence at a depth little, if at all, greater than that at which the temperature would suffice, under merely the atmospheric pressure, to fuse the matter of the earth's crust. When it is proved, however, that that crust must be several hundred miles in thickness, the hypothesis of this direct communication is placed much too far beyond the bounds of probability to be for an instant admitted as the basis of theoretical speculations. We are necessarily led, therefore, to the conclusion, that the fluid matter of actual volcanoes exists in subterranean reservoirs of limited extent, forming subterranean lakes, and not a subterranean ocean. Such also, we conclude from the present thickness of the earth's crust, must have been the case for enormous periods of time, and consequently there is a very high degree of probability that the same was true at the epochs of all the great elevations which we recognise, with the exception, perhaps, of the earliest.'"

Mr. Maclaren proceeds to develop, at considerable length, and with much interest, how these views of the origin of volcanic agency conform with many phenomena of elevatory movements, of earthquakes, and of *local* elevation and *local* subsidence ; and concludes his paper as follows : —

" I shall advert in the briefest terms to some hypothetical views thrown out by Mr. Hopkins, as to the changes of form the globe has undergone. If the earth was originally fluid, it might pass to the solid state in two modes. The heat would be continually dissipated from the surface, and would therefore be greatest at the centre ; and so long as the mass was fluid, the inequality of the heat would cause a constant circulation betwixt the surface and the centre. Now, if the effect of heat in preventing solidification was greater than the effect of pressure in promoting it, solidification would begin at the surface, where a crust would be formed, and would constantly increase in thickness, by layer after layer added to its under side. But if the effect of pressure in promoting solidification was greater than the effect of heat in preventing it, solidification would begin at the centre and extend outwardly. While the process was going on, circulation would continue in the fluid part exterior to the solid nucleus. But before the last portions became solid, a state of imperfect fluidity would arise, just sufficient to prevent circulation. The cooled particles at the surface being then no longer able to descend, a crust would be formed, from which the process of solidification would proceed far more rapidly downwards, than upwards from the solid nucleus. Our globe would thus arrive at a state in which it would be composed of a solid exterior shell, and a solid central nucleus, with matter in a state of fusion betwixt them."

The whole of this very original series of speculations by the Cambridge mathematician, are most worthy of the attention and serious consideration of Geologists.

II. POISSON'S VIEW OF THE ARGUMENT FOR THE CENTRAL HEAT.

Poisson's remarkable work on Heat, has scarcely received justice in this country. Though full of most valuable doctrine alike as to meteorology and the ultimate problems of Geology, a knowledge of it is still, to a large extent, confined to those who can follow his abstruse analysis. I hope to be able at an early period to present much valuable matter from it in a volume I am preparing on "General Laws in Meteorology;" and in the mean time would earnestly claim attention for the following reasoning, on a subject to which I have alluded in the text. He had referred to the problem of the figure of the planets considered hydrostatically, and then proceeds to regard them as condensing aeriform masses. I need scarce remark how much his views cohere with the important part of Mr. Hopkins's conclusions.

"That we may think definitely on the subject, let us assume the well-known hypothesis of Laplace concerning the origin of the planetary bodies, according to which they are portions of the sun's atmosphere, successively abandoned as it concentrated itself around that star. The earth was thus originally an aeriform mass, of immense volume compared with that which it now has, and formed of all its existing solid and fluid constituents, then in a state of *vapour*—that is to say, in the state of an aeriform fluid, whose density, at any given degree of heat, could not pass beyond a certain fixed limit, and which, therefore, became liquid or solid on augmenting the pressure to which it was subjected, without, at the same time, altering its temperature. The temperature of the earth *then* depended on the place it occupied in space, and its distance from the sun, and might be more or less elevated. But, besides those attractions and repulsions existing between the molecules in immediate proximity, and which produce the *elasticity* of aeriform fluids — a force always equal and contrary to the pressure they sustain — the molecules of the earth were then also, as a mass, subjected to their mutual attraction, according to the inverse square of the distances (the general attraction of *gravitation*;) and this force would determine a certain pressure for each bed of the fluid mass—a pressure which, from 0 at the surface, would increase towards the centre, where it would be very great, probably surpassing 100,000, the pressure of our present atmosphere. Now it is this INCREASING PRESSURE, and not the fact of the *existence of a low external temperature* around the aeriform sphere, which has reduced successively all its beds to the solid state, *beginning with the central masses*, and gradually proceeding towards the surface, until nothing unsolidified remained except our seas and the air. This revolution, however, could not be instantaneous; for a certain time would be required to enable each bed to approach the centre, towards which it was pushed by the pressure it experienced, and which was the true *moving force* of the phenomenon. Now one may quite conceive, remarking the almost infinite velocity of *radiation*, that this time or interval must have been altogether sufficient to permit the beds or concentric strata of the earth to get rid of the heat developed during their solidification, by radiating it through the upper beds, still in a vaporous or aerial form; so that there cannot be supposed to remain at the present moment, nor at any definite point of past time, the slightest trace of that heat, how great soever it may have been. An effect similar to that now described would ensue, in the case of a cylinder of great length closed at both ends, and filled with the vapour of water at the maximum density corresponding to the external temperature. Were the cylinder *horizontal*, the weight of the fluid could have no influence; but if it were raised up and placed vertically on one of its ends, its weight would produce a pressure on its different beds, increasing from the top downwards: and through effect of this pressure, liquefaction would take place, beginning on the lowest part of the tube and proceeding upwards. The time occupied by each bed or stratum in descending would not be easy to determine: but certainly it would suffice to permit the latent heat, developed by the bed liquefied immediately before, to escape by radiation through the sides of the tube, or even through *its top only*, should there appear no obstacle to radiation; and thus the water evolved from the vapour *would not be heated*, but would simply preserve the temperature of the external space.

"Abandoning, then, the CENTRAL HEAT, as the origin of the elevated temperature of deep pits, I have proposed another explanation of the phenomenon, founded on a cause whose existence is certain, and which certainly would produce an effect similar to the observed one. This is the inequality of the heat of the regions traversed by the earth, while moving with the sun and his system through space, with a velocity which observation has not yet determined. The temperature of any part of space, or that which a thermometer would indicate if placed at any point in it, is produced by the radiant heat crossing it in all directions, and emanating from the different stars. These bodies form around every point of space an immense enclosure, shut up on all sides; for, on drawing from this point, in any direction, a straight line indefinitely prolonged, it will always be stopped by meeting some star, visible or invisible. Now, whatever its form or dimension, if this enclosure had throughout the same temperature, that of space would be throughout the same; but it is not so—the heat belonging to each star, as well as its light, is caused by its individual character, and these incandescent bodies do not tend to assume the same temperature through the interchanging radiation of their rays. The temperature of space thus must vary at its different points; but, in consequence of the immensity of the starry enclosure, no variation can be sensible, unless when points at vast distances from each other are compared. Through the extent of the earth's annual orbit, that temperature shows no change; but that of the remote regions, passed through by the sun and planets during their common movement, cannot be constant; and hence the earth, as well as all the planets, will undergo corresponding variations. But it is manifest, that, in consequence of its massiveness, the earth would not, on the moment of passing from a hot to a cold locality, lose all the heat it had previously obtained; and that, exactly like a body of considerable magnitude transported from the equator into our climate, it would, on reaching the colder region, present the phenomena at present observed, of a temperature increasing as we descend beneath its surface. If, through effect of its movement through space, it had passed from a cold to a hotter region, the contrary would have taken place.

"We can know neither the magnitude nor the periods of these variations of temperature; but, like all the other inequalities of long periods—like that, for instance, which would come from the secular displacement of the ecliptic, if it were at all sensible—they will extend to very great depths, but not to the earth's centre, nor even, perhaps, to a distance from the surface which would constitute any considerable part of the globe's radius. The increasing or diminishing of temperature accompanying them would extend beyond all depths accessible; at a certain distance it would attain its *maximum*—it would change then into a decreasing or an increasing, and then would disappear entirely. . . . .

"Such, in my opinion, is the true cause of the augmentation of temperature found along every verticle as we descend below the surface of the globe. According to this theory, the mean temperature of the surface must vary with extreme slowness, but incomparably less than that part of the temperature which would be owing to the central heat, if it were sensible, at the present epoch. Besides, this variation may *alternate*, and thus may explain some of the revolutions which the surface of our planet has undergone; whilst that part of the temperature which might arise from the former cause must diminish continually, and show no alterations. If the increase observed, as we described, came in reality from the central heat, it would follow that, on the epoch now existing, the heat of the surface is augmented by the heat a certain fraction of a degree; and in order that this augmentation be reduced one-half, more than a thousand millions of centuries must elapse; so that, to go back to an epoch at which it could have appreciably affected geological phenomena, one would require to pass through a number of ages which must stun the boldest imagination, whatever may have been its former notion of the antiquity of our planet."

It is scarcely necessary to state, that parts of the foregoing note must be understood merely as Poisson's conclusions—the proofs being omitted. Nor must his latter remark be assumed as any reasonable ground of judgment, either one way or other: we can draw no safe conclusion from supposed limits to the antiquity of the earth—measured by their power to "stun the imagination." The paper, however, is pregnant with suggestive thoughts.

III. KIELHAU'S SPECULATIONS ON METAMORPHIC ROCKS.

That the crystalline rocks passed necessarily from the fluid or molten into the solid state, has been for long received in geology almost as self-evident, and this appeared a very strong argument on behalf not only of the molten condition of the central portions of the globe, but also that the crust must have been very thin at comparatively recent epochs. The accuracy of this view was, I believe, first authoritatively impugned in this country by Mr. Lyall, when he insisted so strongly on the theory of *metamorphism*, or of the change of the character of rocks while solid. Professor Kielhau has gone much farther, on the ground of observation, in the rich field of Scandinavia. The following extract from one of his valuable Memoirs will explain his views, and should be read with deep attention.

"There are, indeed, not a few mountain rocks which, either themselves, or their complete analogues, are formed before our eyes by processes whose general nature cannot admit of a doubt. A multitude of other mineral masses, however, and, among them, precisely those which play the most important part in the structure of the earth, viz., the greater part of the crystalline rocks, have an entirely hidden origin and development. The direct observation of the mode of formation of these is so difficult, that it has not yet been definitely determined (for I must be allowed this assertion) to which principal class the agent belongs that has here specially been in operation. It is more particularly with regard to these mountain rocks that the method of investigation hitherto pursued must be changed in the manner already indicated. More diligence must first be employed than has hitherto been bestowed in the discovery of all the geognostical relations presented by these rocks; and, at the same time, in the decision of debatable subjects, greater influence must be given than heretofore to the results obtained by means of unprejudiced observation. It is especially requisite to beware of the principle, that chemistry alone can and must decide in such matters; for, although the laying down of this maxim as a fundamental truth has been believed to be the perfectly philosophical mode of going to work, it may nevertheless turn out to be incorrect. Inasmuch as chemistry has artificially produced the analogues of some of those minerals of which the problematic mountain rocks are composed, it can, without doubt, point out with certainty, particular modes by which Nature may have operated in the formation of such minerals; but can we depend upon chemistry being able to point out all the modes of operation it is possible for Nature to have employed in such cases? And if this were taken for granted, how can chemistry decide as to which of these was actually employed in the instances in question?

"Chemistry already points out more than one way in which such minerals as are now under consideration may have been produced, so that there may really be more than one mode of formation; and, as that science is itself only in a state of progression, it is possible that afterwards it may be able to indicate other processes besides those already discovered. But perhaps those very modes of formation to which the rocks in question owe their origin and development, may, even in time to come, remain undiscovered; for chemical knowledge of this kind rests on experiment, and it cannot well be assumed that Art will ever have it in her power to apply all the means by which Nature herself has operated in her great laboratory.

"But let us assume that every mode is known by which the minerals composing granite, basalt, crystalline limestone, &c., could have been formed. How, I would ask, can chemistry determine which of the processes Nature has followed, when, in the production of these rocks, she effected the formation of the minerals of which they are constituted? We remarked that the rocks of which we are now speaking had an obscure origin and development; the process by which they became what we now find them is concealed from direct observation; there is, therefore, no other method of determining which of the various possible modes of formation was in such cases the true one, except the investigation of the geognostical phenomena, viz., of the forms of the masses, and of the whole circumstances of their occurrence. But this is just a work which does not at all belong to the chemist, as such. When we really see chemists employed in answering the question I have mentioned, this takes place, inasmuch as they then make their appearance in the character of geologists. That people should be deceived in this matter is really very extraordinary. That, for example, in the discussion on crystalline limestone, the chemists have declared themselves in favour of the opinion that this rock generally owes its formation to heat, has hardly been caused by a single purely chemical consideration. Is it at all more probable, for chemical reasons, that the calcareous spar (which undoubtedly has in many instances been produced without the acting of heat) composing, with its small individual crystalline portions, the granular limestone, should have been formed in what is termed the dry way than in the moist? Certainly not. It is known, that in the last mentioned way such a mass can even be produced artificially. As already remarked, it is not chemical reasons which have determined that opinion, but it is speculations belonging entirely and alone to the peculiar province of geology which have called it forth from chemists. It is only a dilettantism in this interesting science to which we owe this and similar judgments, before which even geologists, according to the philosophical maxim already quoted, bow with a loyalty that is even regarded by them as a matter of no small pride.

"The volcanists should reflect well on the following:—That in so far as chemists adhere at present, as they will perhaps do for some time to come, to the hypothesis of the pyrogenic origin of granite, the reason of this can be no other than that they have declared for this opinion *in the character of amateurs of geology;* for there assuredly exists no necessity arising out of chemistry itself for adopting this view. By the side of the celebrated fact, which showed the possibility of the formation of felspar "by heat," that fact, by means of whose discovery volcanism was enabled to boast of its greatest triumph over its old opponents, chemistry itself now places experiments, which prove the possibility of producing felspar in the moist way. That notwithstanding this, chemists who are perfectly impartial with regard to geological disputes, when they have only to choose between the Wernerian doctrine as to granite, and that which prevails at present, would have no hesitation in declaring for the latter, is apparent; but that they will not assert that the latter view is *absolutely* the right one may well be concluded from the advances which have lately been made.

"We may hope that these very advances in chemistry itself, will contribute to show that the relation which must exist between that science and geology has hitherto not been properly understood. In investigations respecting these problematical crystalline rocks, and other mineral masses of still uncertain origin, chemistry can at most only afford geology suggestions or considerations. It is for geology itself, with the assistance of geognostical investigations, to examine to what extent the explanation proposed and the theories advanced, are correct or not. But then it is chiefly requisite, in reference to the phenomena existing in Nature, to acquire that kind of knowledge which is pure matter of fact; for, should this knowledge of natural phenomena really become the touchstone of theories, good care must be taken that the former is not by anticipation modified by the latter."

CHAPTER V.

THE NATURE OF MATERIAL EVOLUTIONS AS MANIFESTED BY THE PHENOMENA OF LIFE.—RESTRICTIONS AND USES OF SPECULATIVE COSMOLOGY.—CONCLUSION.

And now, at this close of our speculations, what mean those gorgeous material changes, leading us, by solemn steps, every where back into the Infinite? Do majestic firmaments transmute and evolve, concentrate towards a state apparently final, but perhaps only a novel point in some inscrutable career;—do they unwind themselves like scrolls, or break up into parts as the spiral Nebula and our Milky Way, only that Space may be crowded with puzzling diversities? Does rock follow rock on our globe, and mountain mountain;—have we continents of capricious shape, at one time encircling the south pole, and again an irregular girdle around its opposite, simply that change may follow change, and clangour drive away silence? Restore us the Nebular Hypothesis even,—dissolve these fair worlds into vaporous expanses, wherein, as in true chaos, the elements intermingle without relationship,—realize their growth towards solidity through ages lying deeper still than those depths from which, in hopelessness, we have just turned away,—and yet what more in effect have we discerned concerning the significance, not to speak of the *necessity*, of this array of phantasms? Profounder, alas! profounder far than human intellect can fathom, lie the solutions of questions like these! The problem of FINAL CAUSES, or the unfolding of all the purposes of the Creator, must, even in regard of the least of his acts, continue insoluble, until some faculty shall have been reached that can discern each act in its *completeness*, or in its connexion with three infinitudes,—the Infinite Past, in which it has its roots,—the Infinite Present, through which its actual form and existence diffuse their relationships,—and that Infinite Future, whose course, according to its efficacy, it must modify. It is only through contemplation of small parts of this vast domain, that glimpses of purpose reach us; and these sometimes, in reverent faith, we venture to stretch over the whole extent and variety of its schemes.

That the Universe is in a state, not of change merely, but of development,—that it is unfolding a grand, though unknown plan, we believe, in obedience to infallible instincts; but, as every phase and form of the material world is replete with its peculiar magnificence and beauty, I doubt if we can attain a definite conception of the essential characteristics of any development considered as *progress*, which is not accompanied with enlarging *enjoyment*, or with the intensifying and expansion of the powers of LIFE. It is to Life, then, and its conditions, that in our present knowledge we must look, as the vivifier of those spaces, and the interpreter of those immense annals. Limited to the inspection of it on the earth, our generalizations must needs be extreme; but by no other road can man reach the dimmest vision of relations between his nature and the stupendous works by which he finds himself surrounded.

I.

That the phenomena of Life constitute, if not an essential, at least an important part of the universal scheme, is confirmed by every aspect of our world. Not only is it now pregnant either with developments of the vital energies or preparations for their advent, but the relics so strangely preserved within its rocks extend the duration of organization back almost to the earliest legible page of its annals. It is indeed a grave and most difficult question, whether those very low beds, (the lowest of De Beaumont's transition series, Plate XIII.) which contain no reminiscences of Life, have seen its fragile characters obliterated by the process which has so altered their own early structure, or whether they terminate some mighty antecedence in which—as perhaps with the Moon even now—this globe underwent its fates, unadorned by foliage, and without the presence of any sensitive creature. But the fecundity of subsequent eras is placed beyond every doubt, by memorials which have survived all inorganic revolutions. Those fossil remains which abound in the later stratifications, establish beyond reach of question, the existence at their special epochs, of distinct classes of vegetables or animals; but they ought also to be received as indicative of far more, even of the immense and varied scheme which those epochs contained. No living creature, be it noticed, can exist by itself alone, but only through wide relationships with a large organized nature below it. From that it draws its food, from that most frequently provision for the security of its haunts; and as each of its dependents is the centre of a circle of sub-dependencies, equally essential and peculiar, the existence of one single creature, if wholly understood, and interpreted aright, would lead us to a scheme of interlaced being whose complexity seems inextricable. Science has had no grander triumph in modern times, than when the immortal Cuvier derived from the fragment of a bone, in the basin of Montmartre, the structure and habits of the extinct creature to which the bone had belonged; but viewed in connexion with its entire relations, that relic—had Zoology been skilled enough to trace them—might have enabled us to rescue from the Past, not one organism merely, with its distinctive peculiarities, but entire races that environed it, and by which, as the loftiest of a series of scaffoldings, its wants and characteristics were sustained. It is not, therefore, on an isolated fragment, be it of fish, lizard, bird, or mammal, that we rest with so much wonder, when the rocks that were the earth's surface in those ancient ages, unfold their contents. Exponents of an associated order, these relics recall organizations occupying the whole world, compact and comprehensive as our own, of forms suitable and infinitely varied, and descending also, by degrees nearly imperceptible, from their ascertained loftiest point, down to the feeblest manifestations of life. Strange, indeed, and diverse, must have been those periods, although, in our imperfect knowledge of the finer relationships of Creation, one may dare only faintly guess at them, even through intimations in themselves so significant. The eye, already bewildered among existing forms, and among the marvellous shapes and endless functions of the living realms around us, finds, as it passes backward, universe after universe revealing itself, whose minute characters are unknown, bound to the existing earth by relations definite indeed, but which might easily be supposed to exist across Space as through Time; and which, therefore, it were no great stretch of fancy to imagine a link between us and the distant stars! Worlds, new, and next to inconceivable, rise up and pass before us, sometimes clearly, but oftenest as in a dim and intangible phantasmagoria, even when we touch the theme. Perished for ever, and it may be reabsorbed among the crystalline rocks, are the continents of which the thick Silurian beds are the debris, and whose strata, with the trilobites, formed the neighbourhood of the ancient shores; but as the obscure centuries float by, flashes of wonderful light, though unsteady as a meteor, begin to attract and arrest the gaze. The carboniferous period, with its unexampled luxuriance, first stands forth; and where there are now inhospitable zones, we discern in the midst of that Past, forests of more than tropical gorgeousness. Circumstances changed as time flowed on; physical climate underwent slow modification; and the forests, whose immense relics prove their wide dispersion over the Earth, contracted their magnificence, and merged into a closer similitude to the flora of modern epochs. By and bye a new glimpse of singular clearness again astonishes us, — one to which reference is almost superfluous, as its contents have been pictured so well by the graphic pencil of **Buckland**. During the deposition of the Oolite, the monstrous Ichthyosaurs and Plesiosaurs must have played in the shallow creeks of the sea, and the hideous Pterodactyle — essentially the vampire of the ancient world — governed the region of the air. Strange, too, and surely not without meaning in the history of life's developments, the intermixture here, or rather interfusion in one organization, of characters that now belong to species very far apart;—for we have fish and reptile, and bird and reptile, so inextricably intermingled, that it cannot often be determined on which side the preponderance lies. — Stupendous revolutions evolved themselves again, and for a moment — as during a flash of lightning—the scene resumes its distinctness. On the termination of the Oolite deposits, and their elevation from the floor of the Ocean into the surface of Continents, gigantic creatures lived that we had not seen before; sufficiently indicative, not merely that life was then most prolific, but in part, of the character of its productions in these times. The era of the huge Iguanodon, whose bones and structure were evoked by the genius of MANTELL, from the fluviatile beds of the Wealden, in its turn gives way to others; and after the formation of the chalk, and interruptions whose causes and history must remain for ever obscure, the tertiary epoch is ushered in, crowded with marvels.* Then begins the true period of the mammals; one of fertility so astonishing, that the great quadrupeds still inhabiting the Earth seem only its straggling relics. Creatures of the sea, amphibious monsters, beasts of enormous size fitted for the forest, jungle, or plain, — these possessed the surface of the globe, and held it for thousands of centuries: and, computing from probabilities founded on consideration of the small portion of the Earth whose beds and rocks have yielded these skeletons, it seems that, when we have arranged the whole of it, we must have the resurrection of upwards of three thousand species of extinct mammifers! — Such the dawn of the era within which it is man's destiny to live!

II.

Let us look, however, at these astonishing developments more critically. Our knowledge of them must, from the very nature of the case, be fragmentary; for although each relic is indicative of a profusion of life necessarily associated with it, the palœotologist can never be altogether certain in regard of any epoch, that the fossils he has discovered, are specimens of the highest life it contained. With respect, for instance, to the carbonigenous forests, what is our *absolute* assurance that no feathered tribes warbled there? for, while the mighty flood of the Mississippi now carries along with it the vegetable debris of the continent it drains, and mingles it with the fuci of the gulf stream, so that both, inextricably interfused, prepare a coal bed for future worlds, how evanescent the chance that, in a chaos so huge, the frail relics of the birds of Western America should form a noticeable constituent!

Or turn to the Cambrian and Silurian rocks,—the former scant of life, because deposited in deeper waters—shall we refuse to recognise these as the detritus of continents, simply because their fossils are all marine? It is a fallacy, although countenanced by the ever honoured Humboldt, that the oldest strata arose, not as such beds do now, but as sediments from the troubled waters, which first surrounded the cooling crust of the globe. Nowhere on the visible surface of the Earth, is there a trace of such beginnings: and those rocks—equalling, if not exceeding in thickness, all the superior formations—are assuredly the accumulated wreck of ancient crystalline masses, and it may be also of perished stratifications, washed down by the wearing of unfathomable ages, and arranged in beds by the ocean. Baffled then in our attempt to reach the origin of things, and never assured that the fossils of any system reveal certainly the most important of the organisms belonging to it, it is only with extremest caution that we dare to speculate on the history of Life in our World. Nor, on descending to the examination of the remains already reproduced in such numbers, have we the feeling that we tread on firmer ground. The entire mass of the invertebrated creation seems diffused without observable difference in its orders, through all the epochs of the World. Changes of form indeed are found: some vanish, others are modified, and new ones gradually arise and partake of Life; but, although these transmutations unquestionably follow some mighty plan, it is beyond our power to conjoin them with *progress*, interpreted on any principle apparently intelligible. Ascending above the platform of these manifold races, and contemplating the successive apparition of the vertebrated creations, the most puzzling anomalies continue to meet the eye. How, in the first place, shall we define *progress?* It is not the adaptation of an organism to the purposes of its life, for that every where is perfect. Is it synonymous with enlarging instincts? Or does it consist in a growing command over the realms of Nature? With what line or series then shall we connect the Pterodactyle of the Oolite? There is no motion of which that extraordinary creature could not partake. It could walk, swim, and fly, leap over great spaces, and float in the air sustained as by a parachute; and if its instincts were commensurate with its powers, it stands out wholly as an anomaly—having neither predecessor nor descendant. The scene we are contemplating is in fact every where fragmentary and disturbed: — manifestly partaking of the imperfectness of our apprehension of all the grander operations of Nature; for it belongs to those vast changes amid which man's life is the merest moment — intermingling with the higher events of the Universe, and being affected by its widest laws. But across all irregularity, starts, and strange stillnesses, one indubitable symptom of order is recognisable; for throughout the whole history of the world, vertebrated animals of *rising functions*, and a growing concentration of brain, somewhat regularly, and in due succession, come upon the scene. Fishes are first discerned, — differing only in modifications from the families that now exist. Subsequently reptiles were superimposed, then birds, and then mammalia; changing also down to the present epoch, but so that we can write no history of their instincts. And the long course has terminated in the mean time with Man—the last product of this toil of Ages:—Man, who to the mind and emotions of every creature has added the power of using all, so that they connect him with the INFINITE! For no unintelligible object then has this mighty elaboration proceeded; but how vast the change even since our Ben Nevis ascended from the deeps! Solemn and peaceful has been the progress; as its end, a flash from the Eternal Reason has become incarnate, and through all these spheres and all ages to come — even until Time shall cease — by stages constantly ascending, it is permitted to hope that the Finite Races may farther arise, and their capacities illimitably expand. The slow revolutions of the world, that enclose centuries within their grasp, proceed as before—quietly as the drop falls; the Orb of day, persistent in his mighty course, wheels towards other immensities; remote Firmaments are preparing to assume forms, and endure modifications, new, and yet unknown; all things as well as Life—with Infinitude before them, are working to realize the unfolding and ascending plans of the UNSEARCHABLE.

III.

But although the grand fact established by a review — even so general — intimates PROGRESS towards a lofty end, — irregular it may be as unfolded to human vision, like all stupendous actions toward which manifold, vast, and unknown processes conspire—it does not resolve the mystery of the development of Life. I have said that the Invertebrated Creation, as an immense and multiplex base of Life, is diffused through all the geological epochs in which the relics of organism are preserved, but that its parts are subject to transmutations. With the idea of progress even in the widest definite meaning that can be given to it, we cannot always connect those changes; but nevertheless they are not capricious, but follow determinate Law. Look for instance to the history of the CRINOIDES. Appearing in abundance in the older formations (the upper transition,) they pass through the carboniferous, and those which immediately succeed them, with forms changing, though with no appearance of fading vitality; but as the ages roll by, their numbers diminish, waning through the tertiary deposits; and now, their epoch has passed. Or observe the Ammonites. Not only does the development of this family correspond in character with that of the Crinoides, but its changes of form are so regular, that the fine eye of Von Buch can detect in the shape of an Ammonite the precise period of the world's history at which it must have been developed! Now these are only instances of a career that has been partaken of by the entire living creation: nay, M. Agassiz has recently been constrained to the important conclusion, that "systematic classifications, which are not at the same time the *expression of the succession of families in the order of time*, can no longer be considered as stating the *real affinities* existing among the animals which they embrace." That a conclusion so striking can already be reached seems the more remarkable, as many steps in the course of the actual development must be obscured by frequent and necessary chasms in the visible annals of the Earth. It was Mr. Lyall, I think, who first brought the fact clearly in view, that we greatly err in assuming that the series of sedimentary strata,—

as found even over as large a territory as geology has yet explored — contain a consecutive and entire history of the progress of deposition; inasmuch as the basins, in which these deposits are being laid down, are nowhere constant, or fixed to one locality. A time will come when the Rhone shall no longer lay down the mud, and other relics, borne by it from its highlands, within the area of Lake Geneva; for when that lake, as it must be, is filled up, the impetuous river will travel to the Mediterranean before its velocity is impeded, so as to permit it to get rid of its burden. The rock, which is the subsequent page in the World's annals to that now forming in Lake Geneva, must thus lie far apart from it: and considering the irregular oscillations of the ever-shifting surface of the Earth, one cannot know that, within any considerable epoch, these two formations may, *together*, form part of the *dry land*, and therefore be accessible, with all their contents, to examination. So soon as we recognise in movements of the Continental masses the main element of the Earth's transitions, — for the rise of a Mountain Chain is only an incident connected with the elevation of a Continent, — it must be clear that the fossil relics, though their assemblage were complete, could not exhibit a perfectly continuous history;—nay, who can tell how much of existing apparent incompleteness, or abruptness of transition, may have its solution in the contents of the rocks and great valleys of the Continent, which the sagacity of Darwin descried at present subsiding below the Pacific?—And every point over which the ocean now rolls, may have oscillated like that, and alternated with the land now upheaved, as the theatre on which life's diversities were displayed. It is recently laid down, by Pictet, as having the force of a *Law*, that "the species of animals belonging to one geological epoch, have not existed either before or after this epoch; so that each has special fossils, and identical species are not found in two formations of different age." Now, although this, as a matter of fact, were not, as it is, highly disputable, how unjustifiable, in presence of those necessary and ever-recurring causes of abruptness, to propose it as an absolute law expressive of the evolution of the Earth! Assured that here we are in presence of one of the grander processes of the Universe, let us march to its solution without presumption and careless of dogmatism. It is indeed most vain to entangle it with controversies, which recently arose regarding "Natural Laws," placed in opposition to "Divine Interference;" as if the distinction were a real one, or the all-potent WILL of OMNIPRESENCE required, to create, the aid of delegated agencies!* The mighty problem, whose conditions through advancing knowledge are fast becoming tangible by the human mind, is not to be disturbed or commingled with phantoms drawn from a grave to which philosophy has long consigned the potency of secondary causes. Reaching high and far, wholly beyond the sphere of metaphysics, it inquires whether the development of Sensation, the character of Life and its onward course towards majesty and power, are not inextricably intertwined with the development of the material world; yes! whether, as these firmaments evolve through endless forms, it is not, in so far as the purposes of the Everlasting are revealed, their essential object — the very crown and glory of their being — to diffuse, sustain, nourish, and advance Intelligences with whom ours may mingle in sympathetic and exalting communion, during the peaceful ages of Eternity!

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* I know but one feature separating "Natural" from "Supernatural" Laws. "Natural Laws" designate some order that we completely understand: "Supernatural Laws" signify that the occurrence belongs to some order or plan, all the parts of which we do not see, and therefore do not understand. Surely it is a very limited and feeble Theism, which would debar the effort of human reason to extend the sway of "Natural Laws."

IV.

In regard of all inquiries touching on the origin or grander progresses of things, it must be manifest, I think, that we cannot obtain, nor ought to expect, that definiteness and completion which belong to classifications of facts and impressions discerned by direct consciousness. Whether such inquiries concern the wide stretch of Heaven, enclosing unnumbered systems within its circuit, and vanishing, as we seek to fathom it, among the depths both of Time and Space; or the history of the Earth bearing, as it passes from the dim immensities of the Past, multitudes of living marvels, evolving in slow progression, — every where we are constrained to recognise that, with whatever energy we pursue them, it is, after all, but the strife of a Finite Being contending with the Infinite; and therefore that a sphere, narrower or wider, must unceasingly environ us, at each point of whose surface Reason requires to merge into Faith.

Critically speaking, Cosmogonies, in which I include all extensive generalizations, consist of endeavours to explain the Remote in Space and Duration, by laws or processes whose energy and nature have been deduced from the course of phenomena that are *near;* and, therefore, it is their essential *postulate*—that amid the abysses through which these laws are attempted to be traced, their action is not impeded or overturned by the intermingling of higher principles; and that, of themselves, they undergo no modification. But as this postulate is clearly problematical, no cosmogony resting on it can claim to be considered as more than a *high probability:* and the important truth must be retained steadily in view, lest speculations so wide, and withal so dazzling, withdraw the mind by an undue excitement of wonder, from a right appreciation of the comparative value of its other knowledge, and obscure its relationships with those immediately surrounding schemes, within which our definite duties alike of thought and action unquestionably lie. It is, indeed, a high honour to the Soul to have been gifted to draw near and gaze on the Unsearchable, and to feel its capacity to desire and labour for a farther raising of the

Veil; but as the power with which we thus toil, and the whole light that cheers us in our perilous course, are drawn from the care and success with which we have analyzed those smaller realities amidst which we dwell, it were surely the worst of logic to regard those realities, as if they could be seen aright only from the other extremity of the dim immensities through which, by their aid, we have penetrated, or to bring the august and awful shadows of these dread recesses, to darken the sunshine of the verdant earth! The fallacy I am referring to is no mere chimera; for nothing has been more frequent, either in former times or our own, than for Theorists, impelled by enthusiasm far beyond the limits of Reason, to mistake the place and relation of their theories, —thereby confounding the popular mind, and destroying the rightful claims even of legitimate speculation. But when put directly, and with due clearness, the solution of such questions requires no deliberation. It is undoubted, for instance, that the hypothesis of Laplace regarding the origin of the Solar System, is in itself as fine and complete as any speculation of the kind that has hitherto been received; but assuredly it would have seemed most strange, had some fervid admirer, hurried into an utter forgetfulness of its grounds and essential character, proposed that Astronomers, having abandoned their tables and cast the telescope away, should henceforth study the complexities and facts of our system through the doctrine of its nebulous parentage! And yet the absurdity is none the less, only not so easily recognisable, and of infinitely greater hazard, when cosmogony is adduced in decision of questions concerning the actual NATURE and DESTINATION of Man. In point of strict logic, as soon supplant the labours of Greenwich, and destroy its long records; yea, sink into oblivion the immortal Tycho, with the Halleys, Maskeleyns, Bradleys of former times, and the Bessels and Airys of our own, —even this as soon as discredit Psychology and accept Materialism at the bidding of the scheme of a LAMARCK! Ranking among the grand and indubitable realities of Nature, Man's Essence is fixed, and clear as the Stars; and nothing, save inquiry of itself, will unfold its just proportions. Nay, if the separate departments of knowledge require to be classed, according to their shades of certainty, our knowledge of the human mind, as derived from immediate consciousness, must be held the most certain of all, for it is on the reality and truthful action of the functions of the perceiving agent, as its substratum, that our belief in external realities essentially depends. The sense of Existence, the ideas of Right and Duty, the awful intuitions of God and Immortal Life — these, the grand facts and substance of the Spirit, are independent, and indestructible as the Universe itself. The basis of the Moral Law, they shall stand in every tittle, although the Stars should pass away; for their relations and root are in that which upholds the Stars — even with worlds unseen, and invisible from the Finite, whose majestic and everlasting arrangements shall burst upon us — as the Heavens do through the night — when the light of this garish Life gives place to the solemn splendours of Eternity.

—— Not to destroy, but to invite towards truths high and distant, of which, now, only the shadows are discerned; — not to debase or perplex, but to exalt, and realize — even through these evanescent shows — the highest aspirations of an Immortal; is an Infinitude every where fathomless — of riches ever inexhaustible — spread out around, for interrogation by an expansive and never sated Reason! To pass from what is near and distinct, on to what is remote and obscure, along a course which shall never have a term,—this is the appointed and surely the fitting destiny of a Being whose capacities of improvement are in themselves endless, and which, during its whole glorious Immortality, shall ever approach nearer a full appreciation of that Power, and Knowledge, and Beneficence, which constitute the Divine Nature.

——Even through its dim visions, through its conflict ever baffled with the unfathomable Universe,—even when its doubts increase and its sense of feebleness is growing more oppressive,—with awe how profound, and in admiration how far beyond speech, must the soul bend before Him of whose dread Will these mighty phantasms are but a passing act! Resolving all into one incident amidst Eternity, into a solitary wish of the Ever-enduring, all things else seem to vanish away: and the idea arises in overwhelming vastness, of an All-Sustainer, an All-Preserver, who, uncounselled, unassisted, unchanged and unchangeably for ever more, upholds the fabric even of his own Immutable Being!

NOTE ON CAUSATION.

NOTE ON CAUSATION.

THE *questio vexata* of philosophy—that regarding the Idea of Cause—to which I have referred in the course of the foregoing pages, is beset at once by *real*, and *unnecessary* and factitious difficulties. Those of the latter class seem to arise wholly in the endeavour, which ever must be futile, to deduce the nature of that Idea from *external phenomena;* and inquirers have either misinterpreted what these phenomena exhibit, so that it may seem to include the Idea of Cause, or they have misstated our Idea of Cause, that it might be made to flow from observation of phenomena. There cannot be a doubt, on the one hand, that the outward world contains no indication of any higher connexion than simple sequence; and I think it quite as clear, that although we add the attribute of *invariability*, and conjoin an intuitive expectation of its continuance, we have yet only clothed the Idea of Cause with the best and most accurate form which the language of external representation can enable us to give to it; but have not reached the nature of the Idea itself.

It was the signal merit of the sage of Königsberg to disentangle the confusion to which I have referred, in the simplest and easiest way. Kant stated that the relation of cause and effect, is one under which, in virtue of our constitution, we are constrained to arrange all perceptions; that, just as the construction of a machine determines the form into which the material subjected to it shall be changed—the character of the mind, as a definite and individual thinking organism, must contain powers within itself, to determine the mode in which it must treat its rude sensations. Accepting this lucid expression of the facts of the case, we are rid at once of the necessity of seeking the origin of the Idea among visible mutations; and also of employing the equivocal and in some respects inaccurate language of the contemporaries and successors of the celebrated Reid: but it is evident that Kant only delivered the inquiry from factitious *physical* embarrassments, and that the grand psychological problem remained untouched. What mean we by CAUSE? What is the *root* of this *relation* to which we subject external changes? Is it insusceptible of farther analysis, or is it derived from, or akin to other grand ideas, discernible among the foundations of our Nature?

I have said in the text that POWER seems to me synonymous with the energy of FREE WILL. I cannot distinguish the idea from the conception of a FREE ACT; and if this ultimate analysis is correct, have we no choice but resolve the Material Universe into the *immediate*—as distinguished from the *mediate* workings of the INFINITE and ABSOLUTE MIND. But it must be especially observed, that this resolution extends only to all Nature which is *not Free*, and which has no *individuality*. It is the *Material Forces* only that disappear before it; so that the doctrine cannot be converted into a Pantheism, presenting all things as mere modes of an Absolute, which, as it changes, ever reabsorbs the Past;—and this, because no conclusion can destroy the premises on which it rests. It is from our consciousness of FREEDOM, from our experience of WILL, that we derive our solution of the Idea of Power; and therefore this solution rests essentially upon the individuality of our separate Freedom: the existence of that great and only mystery of the Universe, viz. the consonance of Created Freedom with Absolute and Eternal Will, abides unquestioned and unimpugnable; and likewise the reality and integrity of Man's relations to God, as expressed by the voice of Conscience.

The subject I have been tempted to refer to, bears so closely on speculations regarding the history and aspects of physical inquiry, recently put forth by a very talented Frenchman, that perhaps I shall be pardoned the addition of a few farther remarks. In his division of the history of thought regarding Nature, into the theological, metaphysical, and positive epochs, *M. Comte*, in so far as regards the past, is unquestionably correct; nor is he less accurate in stamping the two former as stages of infancy, leading towards the manhood of knowledge. HOMO MINISTER NATURÆ ET INTERPRES, — the interpreter, and nothing more: and therefore it is only indicative of feebleness, or of that incomplete development accompanying the dormancy of some class of high faculties, when, as in the first epoch, the Inquirer permits theological belief, whether expressed under the form of FINAL CAUSES, or otherwise, to modify his notions or even his expectations regarding the course of Nature; or when, as in the second, he resorts, for the explanation of phenomena, to theories of *external efficient causes* of any description, or to hypotheses unverifiable, and therefore inadmissible. It is through the observation and discussion of phenomena alone — the disentanglement of their sequences—and the discovery of relationships by means of skilful classification and comparison, that positive physical science can be reared; nor, until this is thoroughly apprehended, can the mind of the whole man be accounted active in interrogating and interpreting the Universe: but M. Comte commits an error precisely similar to those which he condemns, and one probably still more grievous, in assuming that the philosophy of sequence—named by him *positive*—must, if complete, contain the sum of attainable knowledge. The momentous question remains, whether we are cognizant of ideas that do not show themselves as sequences; and surely it is not a rude settlement of the difficulty to have the question answered, with M. Comte, in the negative, simply on the ground that *we cannot* *discern them among phenomena or successions,* — the very terms of the inquiry assuming that they are not discernible there! The remarks I have just hazarded regarding the Idea of Cause, sufficiently indicate how very wide my conclusions on this subject are from M. Comte's; and I shall farther add, that his positive epoch is not, nor can be, the conclusion of philosophy,—that a fourth must supervene, whose aim shall be to reconcile and connect the transitory, or a scheme of external mutations, to the Absolute in our own Natures, and to the highest Absolute, even the unchangeable and every where immanent SPIRIT. Already, both in this country as elsewhere, are many symptoms of the dawn of this period of a fresh and re-invigorated philosophy; a philosophy which shall be as free of myth or verbal formality as M. Comte's positive Science, but which, in contradistinction from his ingenious scheme, shall shun no problem connected with the constitution or destinies either of Nature or Man.

Historical eras are seldom pure or limited to the development of a single and simple idea; and accordingly the thoughtful eye will discover, alike among the metaphysical philosophies of Greece, and the theological speculations of our own earlièr times, not glimpses merely, but a strong conviction of the necessity of these ultimate investigations, that the course of things might be intelligible. Among our English divines, of the school of Henry More, especially, the sense of the reality of those grand intuitions was vigorous and fresh; and hence their notion of God's relationship with the course of the world (I do not mean the relations merely usually designated by the word *Providence*) often touched on the sublimest truths, although involving much that could not fail to be erroneous. I am sure many of my readers will not peruse, without peculiar emotion, the following illustrative extract from "Law's Way to Divine Knowledge:"—

"The *Abyssal Will* of God is the ground and cause of *eternal nature*, and of every being, life, and substance that is born out of it. It is the *creating* power and operation of God, whereby all things are brought into existence. The first manifestation of the invisible God, without which He is and would continue to be an hidden unknown God, is that which is called, and is *eternal nature*, as is before declared, which is the eternal fund of all possible qualities of life, the first source of every natural power that can be in any creature. All these qualities of life in their eternal birth, and rising from one another by the *working will* of God, are the *out-birth*, or outward glory of God, in which He manifests His *triune invisible Deity* in a *threefold life of fire, light, and spirit*, which are the *ground* of all the qualities of life, sensibility, power, and spirit, that ever were or can be found in any creature. Every being that exists, thinks, or moves, or is endowed with any kind or degree of life or sense, is from, and out of this *glassy sea* of these united powers of life. This full manifestation of all the possible powers and perfection of life and glory, is called that *kingdom of heaven* in which God dwelleth and worketh, and is a *magical outbirth* or offspring, arising from the *triune working will* of the hidden Deity, which willed to see itself in this opened outward show of all the possible powers of life and glory; and from whence new worlds of finite divine beings, as so many living images of God, might have a possibility of coming forth. For without *nature*, which is the ground of creation, God must be by himself, and continue an unmanifested God. But this same *working will* of the triune Deity, which thus manifested itself in an *eternal nature*, manifested itself also in *creaturely forms*, all generated from, and animated with, that same trinity of fire, light, and spirit, which constitutes *eternal nature*. So that all *intelligent natures* are that in their finite being, which *eternal nature* is in its infinite state. And thus all of them are from God and from Heaven, live in God, and may work with God, as God is in Heaven and Heaven in Him; one life, one power, one will, and one happiness with God. Now every thing that is not God, but posterior to and distinct from him, must be that which it is from the working will of the Deity. For since it cometh into being only because it is *willed* to be, it can have nothing in it, or be any other thing, but that which the *working* or *creating will* brought forth. And as all things began in and from this *working will;* so all things must go on in it; and there can be no other creator, worker, or former of things to all eternity, but the *working will* of God, either mediately or immediately. Nor can there be any other nature in any thing, but that which is the *birth*, or *magic effect* of a *working will* within it. And every thing which is done by the creature, every thing that it seeks and likes, or abhors and resists, is all driven on by a *working will* or *magic power*, which stirs and operates, and works within it. This *will spirit* in the creature, called in things inanimate *attraction* and in animals *instinct*, is that which keeps up the whole system of *stars* and *elements*, with all its creatures, vegetable and animal, in their full conformity to the first *working will* of God in their creation, which is never separate from them. The *will spirit* in the intelligent free creature is of a much higher nature; it has the never-beginning *eternity* in it, and is a genuine offspring of the *will-spirit* of God, and therefore, in its degree, partakes of the power of God over *nature*. The true ground and reason of all which is this, it is because will is the *first original* of all *power*, and the omnipotence of God consisteth in nothing else but His working will: and, therefore, no *power* ever was, or ever can be, any where else, but as it is in God; and if the creature hath any power, it must have it as God hath it, in a working will. For since all *nature*, with all its qualities, births, and creatures, are all brought forth into being by the *working will* of God, it evidently follows that every creature, with every quality, power and property in it, is *magically* born, and therefore must have a *magic nature*, that is, a *nature* that cometh from, and standeth in a working will. So that these words *magic* or *magical power*, mean the *working* or *the work*, either of the divine or creaturely will. And a *magic work*, as implying that which is produced by a *birth* or *growth* proceeding from a *working will*, either in the creator or creature, stands, as such, contradistinguished from those dead works, which are only the operations of men's *hands* and *rational faculties*, on subject-matter already prepared and set before them."

"By nature are meant all the working stirring properties of life, or all the various sensibilities which life is capable of finding or feeling in itself. It is distinct from God; as distinct as want is from the thing wanted. Nature is in itself merely a desire, made up or consisting of the three first forms or properties; God considered in himself is the happiness, the rest, the satisfaction, the joy, and the fulfilling of those properties. In pure unfallen nature God dwelleth, filling, pervading, and blessing with His light and spirit every part of it. Hence is *nature* justly said to be a true *manifestation* of the *hidden invisible power* of God. As sure as there is an *eternal* God, so sure is it that there is an *eternal nature*, as universal, as unlimited as God himself, and every where working where God is, and therefore every where equally existent as being His kingdom of *heaven*, or *outward manifestation* of the *invisible riches, powers, and glories*, of the Deity. Before or without *nature* the Deity is an entirely hidden, shut up, and unknown abyss. For nature is the only ground or beginning of *something*. There is neither *this* nor *that*, no ground for conception, no possibility of distinction or difference; there can be no creature to *think* nor any thing to be *thought upon*, till *nature* is in existence. For all the properties of *sensibility* or sensible life, every mode and manner of *existence*, *all seeing, hearing, smelling, tasting, feeling;* all *inclinations, passions*, and *sensations* of *joy, sorrow, pain, pleasure, &c.* are not in God, but in *nature*. And therefore God is not knowable, not a thought can begin about Him, till He manifests Himself in and through, and by the existence of *nature;* that is, till there is *something* that can be seen, understood, distinguished, felt, &c. And this is *eternal nature*, or the *out-birth* of the *Deity*, called the *kingdom of heaven*, viz. an *infinity*, or *boundless opening* of the properties, powers, wonders, and glories of the *hidden Deity*, and this not *once done*, but *ever doing*, ever standing in the same birth, for ever and ever breaking forth and springing up in new forms and openings of the *abyssal Deity* in the powers of *nature*. Out of this ocean of manifested powers of nature, the will of the Deity created hosts of heavenly beings, full of the heavenly wonders, introduced into a participation of the *infinity* of God, to live in an eternal succession of *heavenly* sensations, to see and feel, to taste and find, new forms of delight in an inexhaustible source of ever-changing and never-ceasing wonders of the *divine glory*. This is *nature* in its *original* and *pure* and *true* state, from eternity to eternity. Nothing else but a mere *infinity* of *heavenly* light, love, joy, and glory, as being the manifestation, dwelling, and working place of the *hidden Deity*, who blesses, fills, perfects, and exalts it by manifesting Himself in it. For the *perfection* of *nature*, as likewise of every divine and happy creature, is an union of *two* things, or is a twofold state. It is *nature*, and it is God *manifested* in *nature*. The Deity is an infinite plenitude or fulness of riches and powers, in and from itself; and it is only *want* and *desire* that is excluded from it, and can have no existence in it. And here lies the true immutable distinction between God and *Nature*, and the reason why neither can ever be changed into the other. It is because God is an UNIVERSAL ALL, and *Nature* is an UNIVERSAL WANT, viz. to be filled with God. In the *pure eternal nature*, or in *eternal nature* as it stood in its first original state, and now stands in the kingdom of heaven, this distinction between God and *nature* is not perceived, because God is not known as separate from *nature*. But in *nature* spoiled and corrupted by the *fall* of the *creature*, this distinction is perceived and felt; and nature is found to be nothing else but a state of mere *restless*, *anxious*, and *unsatisfied desire*. Which is what is to be understood by the *centre* of *nature*, *dark centre*, centre, source, or principle of wrath, wrathful matrix, first principle, and abyss of anguish or hell.

For a centre signifies a principle, source, ground, or original of life and motion. And therefore the *centre* of *nature* means and implies the three first *forms* or *properties*, of *nature* or *desire*, which are, 1. A continual spiritual *compression* or *thickening*, which constitute the *darkness* and *substantiality*. 2. Motion or resistance to this compression or thickening, which is the *ground* of all *sensibility*. And, 3. A restless incessant state of whirling, caused by those two first properties, which is the very *nature* and *power* of *life*. Now these three properties of *nature* or *desire* are that *sufficient something*, in which the Deity by entering into it, could and did manifest his *hidden power*, by turning it in its different workings into an endless variety of delightful forms and sensibilities of the *creaturely life*. They (the three first properties of nature,) were never to be seen or known as they are in themselves, by any creature. Their thickness, strife and darkness, were brought forth by God in union with the light, glory, and majesty of heaven; and only for that one end, viz. that the Holy Deity might be made *manifest* in them."

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